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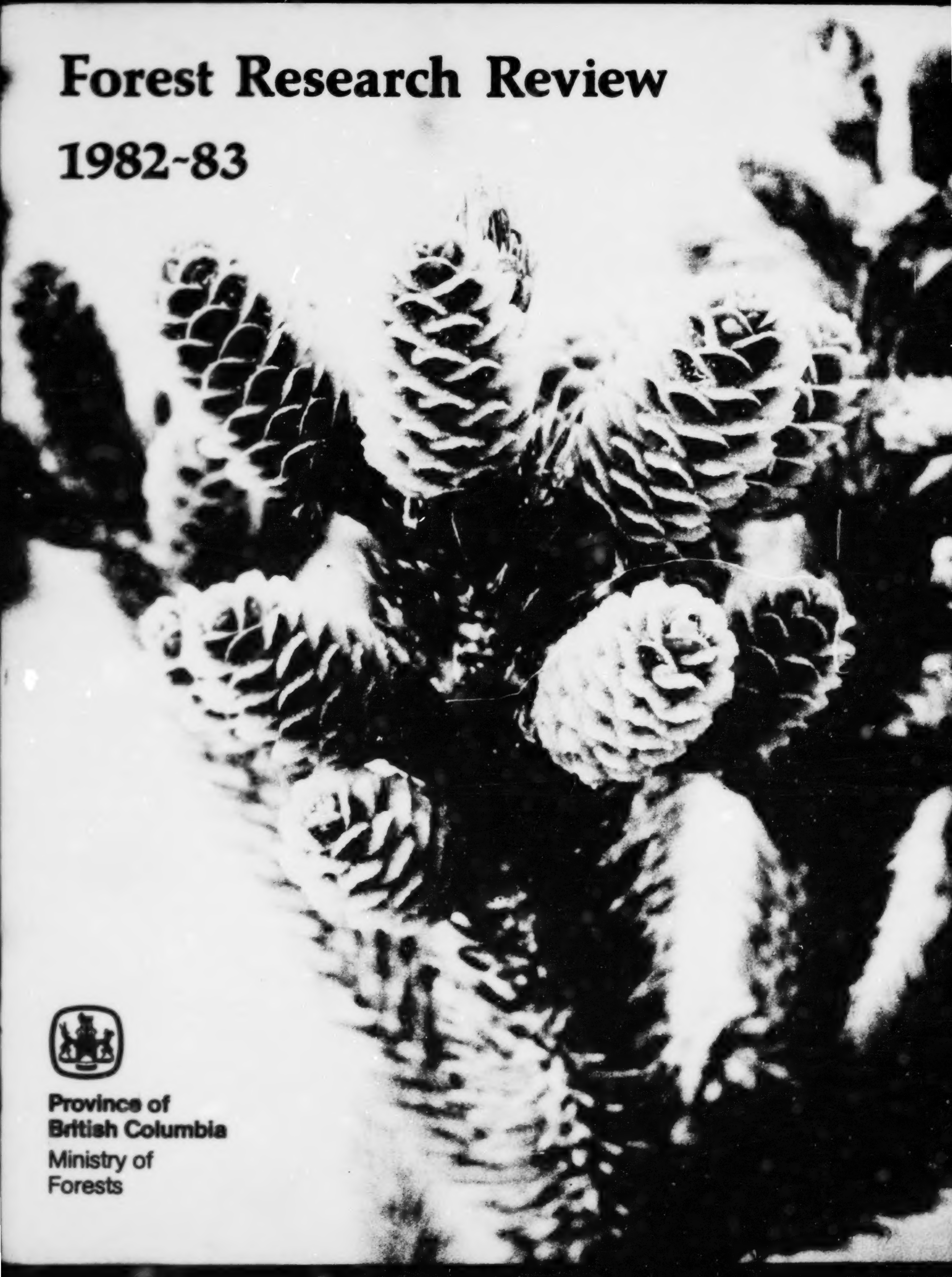
1982-83



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DIRECTOR'S REPORT

Research Program expenditures in 1982/83 amounted to 8.9 million dollars which included 6.8* million for headquarters research, and 2.1 million for regional research. Other research expenditures were harvesting 0.5 million, and Section 88 (licensee) research 0.4 million dollars.

In 1982/83 the Research Program like many programs in the Ministry of Forests was faced with the challenge of operating with a reduced level of funding from the previous year. For the most part this was accomplished through reduced expenditure on capital projects and implementing a variety of other cost saving measures. While this has not been without impact, the research staff have risen to the challenge. The success with which they have met this challenge is demonstrated in their many major accomplishments. During the past year 45 published reports and 47 special purpose unpublished reports documenting research results were compiled. In excess of 1000 individuals from government and industry were trained in a wide range of topics such as, ecosystem identification and use in forest and range management, hydro-seeding in erosion control, and determining cone and seed maturity for harvest timing.

The tree physiology program made several significant strides in the past year. A long standing study of the reproductive anatomy of all commercially important B.C. conifers was completed. A new greenhouse complex was completed for the container seed orchard research project. The group was successful in inducing profuse male and female flowering on young potted white spruce ramets for the first time. Similar work with western hemlock has demonstrated retention of vegetative vigor with excellent biennial cone induction. Flower induction research with western redcedar has made it possible to recommend a reduction in size of seed orchards for this species. Ongoing research on seed pelleting has progressed to the stage, with western redcedar, where semi-operational trials of machine sowing can now be established and bareroot seed-bed density research has been extended to successful operational trials of large seeded species. In 1982/83 a modest beginning was made in establishing a research project designed to examine impacts of long-term winter cold storage on white spruce stock quality.

A highlight of the Ecology and Earth Sciences program was the Grassland Ecology and Classification Symposium held in Kamloops which brought North America's best expertise together to discuss British Columbia grasslands.

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*includes $247,500 received from Canada Department of Fisheries and Oceans, and Ministry of Environment in conjunction with the cooperative Fish/Forestry Interaction Program on the Queen Charlotte Islands.

In keeping with the effort to develop a sound range management research project, the problem analysis on range management information and research needs has progressed well and is nearing completion.

Another significant and long lasting contribution was the preparation, by staff from the Ministry's Ecology and Earth Sciences program, of the chapter on Forest Ecology in the new U.B.C. Forestry Handbook.

1982/83 marked the formal initiation of the Fish/Forestry Interaction Program on the Queen Charlotte Islands. The program's four major studies were initiated 1) synoptic survey of streams, 2) stream and forest rehabilitation studies 3) silvicultural investigation and 4) alternative logging studies.

In following up on the rigorous review of all breeding strategies and programs that took place in 1981/82, a new breeding program with Interior Douglas-fir was begun and a new geneticist was hired for the lodgepole pine breeding program. Also of major significance this year was the collection of 15-year results from the Interior spruce provenance program and 10-year results from the first series of open pollinated progeny tests. Results from this have been used to identify clones to be used in establishing 1.5 generation orchards to supply genetically improved seed for some five seed orchard planning zones. The information will also be used to allow a revision of spruce seed transfer rules.

In keeping with the Research Branch responsibility to conduct all grafting for the Coastal Tree Improvement program, Cowichan Lake Research Station propagated 25 000 grafts of eight tree species this past year.

Activities in forest regeneration research continued to expand in response to the Ministry's emphasis on meeting basic silvicultural goals and the associated need for effective crop establishment methods. Seven new studies were initiated, encompassing a wide range of treatments: herbicide, mechanical site preparation, large planting stock in the Prince Rupert and Prince George Forest Regions. New planting studies were also established to investigate factors such as species choice, stock type, timing of planting, effects of fertilization at time of planting and nursery treatment in Cariboo, Kamloops and Nelson Forest Regions.

In the Vancouver Forest Region, work began on developing guidelines for operational planting of noble fir and for fall planting.

Progress was made on the issue of forest vegetation management with the completion, under contract, of a problem analysis on forest vegetation management research needs, education and training in B.C. Concurrently a draft working plan for vegetation management screening trials was completed.

A major review of all older Growth and Yield (spacing and thinning) Experiments was completed and the associated tree data from each plot has been compiled, edited, documented, and summarized according to the format recommended by the Committee on Standard of Measures and Data Sharing (COSMADS), Western Forestry and Conservation Association.

Requests for technical advice and consultation on vegetation establishment techniques and methodology to control erosion associated with timber harvesting activities continue to increase. The basic set of reference hydroseeding test plots is now in place, which will enable validation of interim prescriptions.

TREE PHYSIOLOGY

L.F. Ebell, Ph.D., Manager

Research in the Tree Physiology Section is of an applied nature. Studies are directed at improving forest regeneration through the solving of technical and biological limitations encountered in all phases of the life cycle of British Columbia conifers.

Facility improvements in 1982/83 included construction of three 12x24 m wooden arch rib polyethylene greenhouses, a 12x18 m post and cable shadehouse for container seed orchard research, and five 6x12 m pipeframe polyethylene greenhouses for nursery research and growing of special test stock for problem sites. A fully automatic atomic absorption spectrophotometer was installed to assist with the analytical laboratory's growing workload.

SEXUAL REPRODUCTION

Reproductive buds of western hemlock were finally obtained after many years of sampling, enabling completion of reproductive anatomy studies of all commercially important British Columbia conifers. This information has been invaluable in defining the timing for control of flowering treatments, which is important to tree improvement research and seed orchard management.

Further container seed orchard research with western hemlock has demonstrated retention of vegetative vigor with excellent biennial cone induction. The system is being used to advance the hemlock breeding program and to provide research material for pollen management studies. Profuse male and female flowering of potted white spruce ramets was achieved for the first time and, if reliably repeatable, procedures could revolutionize seed procurement, chronically short for this species. Flowering experiments on western redcedar have enabled great reductions in seed orchard area. This prescription has been adopted ahead of the first seed orchards for this species. Similar management of yellow-cedar seems feasible.

Pollen respiration measurements provided a highly significant relationship to seed set in Douglas-fir, in contrast to other measurements tested. Seed set in western hemlock-controlled pollinations increased progressively with applications up to 8 days after seed cone bud burst. This differs from Douglas-fir in which maximum receptivity is obtained from pollination within 2 days of bud burst.

CONE INITIATION AND SEED DEVELOPMENT IN MOUNTAIN HEMLOCK (E.P. 738) J.N. OWENS

Vegetative bud development

Vegetative buds of mature *Tsuga mertensiana* (Bong.) Carr. (mountain hemlock) were studied throughout the annual growth cycle. Vegetative buds became mitotically active in mid-April and shoots and leaves elongated within the bud scales causing the buds to burst in late June. Lateral shoots completed elongation by the end of July. Vegetative terminal apices from lateral branches began bud scale initiation when bud dormancy ended. All bud scales were initiated by the end of July. Leaf primordial initiation occurred from that time until mid-October when vegetative buds again became dormant. Axillary buds were initiated on the elongating shoots in early June, and then followed the same phenology as vegetative terminal buds. Vegetative bud and shoot development are compared to that of western hemlock and certain other members of the Pinaceae. The relationship of bud development to shoot development was investigated for mountain hemlock and other conifers having a similar pattern of vegetative bud development.

Cone initiation and predormancy cone development

Seed cones occur terminally on distal lateral branches and form from the differentiation of a terminal, previously vegetative apex, into a seed-cone apex. Pollen cones commonly occur on lateral branches and form from the differentiation of an undetermined axillary apex about 6 weeks after axillary bud initiation. Pollen cones also occasionally occur terminally. All cone buds began differentiation in late July after bud scale initiation was complete and at about the end of lateral shoot elongation. Seed-cone buds initiated bracts and ovuliferous scales, but not ovules, before they became dormant at the end of October. Pollen-cone buds initiated all microsporophylls by early September. Microsporangia containing microspore mother cells differentiated before pollen-cone buds became dormant in mid-October. The time of cone-bud differentiation is related to vegetative bud and shoot development. The time and method of cone-bud differentiation was investigated in relation to western hemlock (*T. heterophylla*) and other conifers having similar bud development.

Development of the pollination mechanism in mountain and western hemlocks

Pollen of western hemlock is nonsaccate and bears spines, whereas pollen of mountain hemlock is saccate and lacks spines. The pollination mechanism in western hemlock consists of a short funnel-like integument tip with a large micropyle. Pollen may enter the micropyle or germinate on the bract or ovuliferous scale and form long pollen tubes. The pollination mechanism in mountain hemlock consists of two large micropylar flaps that secrete minute droplets to which pollen adheres. A pollination drop is not formed in either species. These features were investigated in relation to the taxonomy of the genus and the reproductive biology of these two species.

CONE INITIATION AND SEXUAL REPRODUCTION OF *Picea engelmannii* (E.P. 900)

J.N. OWENS

Vegetative bud development, differentiation and early development of reproductive buds

Vegetative buds of Engelmann spruce from the Prince George Forest Region (British Columbia) were collected and studied. In mid-April dormancy ended as determined from mitotic divisions within the leaf primordia; two weeks later mitotic activity occurred in the bud apices. Bud scale initiation began in terminal buds by late May followed by that in axillary buds two weeks later. Shoot elongation began in late May, bud burst occurred in late June and both shoot elongation and bud scale initiation were complete by late July. Terminal buds began to differentiate, by the initiation of leaf primordia, into vegetative buds early in August whereas axillary buds began to differentiate one week later. Leaf initiation was completed in all vegetative buds by late September and buds were dormant by mid-October.

Differentiation and early development of reproductive buds

Pollen cones initiated microsporophylls after bud scale initiation. Microsporangial initiation began in late August. Microsporangial enlargement began in mid-September and continued until dormancy when pollen mother cells were observed in a pre-meiotic stage.

Seed cones initiated bracts directly after bud scale initiation. In mid-August, ovuliferous scales began to be initiated. Two ovule primordia formed adaxially. Each ovule formed one large central megaspore mother cell which overwintered in a pre-meiotic stage.

ENHANCEMENT OF CONE PRODUCTION IN SEED ORCHARDS (E.P. 799) J.E. WEBBER

Preliminary results for E.P. 799.02 were reported in the 1981/82 Forest Research Review. Final field assessments have now been completed and are documented in a progress report. A final summary of these results is as follows:

Gibberellin and root pruning treatments were applied in a 2 x 2 factorial design tested on two groups of 9- and 10-year-old half-sibling seedlings grouped according to the families past history of flowering. Results were analysed as a three-way factorial with families' crossed with $GA_{4/7}$, root pruning, and the history-of-flowering factor nested within families. Root pruning was accomplished using a vibratory plow, modified with a special blade, to produce a box-pruned root system. Gibberellin ($GA_{4/7}$) solutions were applied using a continuous stem injection technique (50 ppm). Root pruning was done in April 1981, about four weeks before vegetative bud flush. Gibberellin treatments began in the middle of May to coincide with vegetative bud flush, and continued for 7 weeks.

Growth of lateral shoots was monitored on four branches of the third whorl and was measured weekly from bud flush to the end of shoot extension. Flowering response was assessed in March 1982.

Flowering was significantly affected by the $GA_{4/7}$ and root pruning treatments, and the magnitude of this response was mediated by the trees' previous flowering history. Root pruning resulted in a significant 69-fold increase in total seed-cone bud production in poor flowering trees. Gibberellin treatment was less effective (about a two-fold increase in poor flowering trees), but when combined with root pruning treatments produced a dramatic synergistic effect resulting in a 250-fold increase in total seed-cone bud production for poor flowering trees.

The root pruning and gibberellin trial at the Snowdon Seed Orchard (E.P. 799.03, 1981) supported the results for E.P. 799.02. Root pruning alone produced an average of 3.25 seed-cone buds per whorl branch and nearly five seed cones per branch when combined with gibberellin treatment. Although the synergistic effect was not as large as in E.P. 799.02, this result was not unexpected since the 100 ppm foliar spray used is much less effective than the previously used intra-vascular technique.

CONTAINER SEED ORCHARD RESEARCH (E.P. 865) S.D. ROSS

Additional studies conducted in 1982 (E.P. 865.05, .06 and .07) further confirm the potential that containerized orchards offer for accelerating the production of improved western hemlock seed. The technique was also successfully used on a limited scale to advance the western hemlock breeding program (E.P. 865.07), and this application of containerized orchards will be expanded in the 1983 growing season. The studies also dispel earlier concerns (see 1981/82 Forest Research Review) that the potted trees may require several years following cone-induction treatment to regain sufficient vegetative vigor and regeneration of new shoots before they can be safely and effectively retreated. With proper control of temperature, water stress and fertilizer levels, it is possible to induce profuse flowering while still maintaining plants in a healthy condition. However, for sustained high productivity, a year of vegetative recovery between treatments still appears necessary to replenish the large proportion of shoots which will have been turned reproductive.

Water stress greatly enhanced the flowering response of potted western hemlock ramets to $GA_{4/7}$ applications. A combined treatment lasting 12 weeks was much more effective than one lasting only 6 weeks (E.P. 965.05). Since other studies have shown that maximum promotion of flowering by $GA_{4/7}$ is achieved after only 6 weeks, the present finding may suggest that the optimum duration for water stressing is longer, or that the stress treatment is more effective at a later stage of cone-bud development. Results of a 1982 growth chamber study in collaboration with the Pacific Forest Research Centre (E.P. 865.06), in which heat stress was applied at different phenological stages, should help resolve this question. From E.P. 865.05, it is important to note that water stress was more effective than heat stress as an adjunct to $GA_{4/7}$ in the promotion of flowering in western hemlock. Both female and male flowering was decidely superior for potted ramets treated out-of-doors than within either an unheated or heated shelterhouse (E.P. 865.05). This observation has significant economic implications as the shelterhouse represents a major cost factor in container seed orchards; however, confirmation is needed over a range of climatic conditions of several years.

Success was also achieved -- and for the first time -- in inducing profuse female and male flowering in potted white spruce ramets (E.P. 865.04). Although results have yet to be fully analysed, it appears that both high temperature within a heated shelterhouse (30°C days/20°C nights) and a moderate level of soil water stress is required for maximum flowering. The latter half of shoot elongation appears to be the optimum time for induction of seed cones, whereas earlier treatment is more effective in the promotion of pollen cones. The increase in flowering due to $GA_{4/7}$ was generally small, and further research on hormone formulations and application techniques is required to optimize the treatment for white spruce (see E.P. 935). Pollen has been collected from potted trees in another study (E.P. 935.04) and used to supplementally pollinate the induced female flowers.

HORMONE TREATMENT METHODS AND REGIMES FOR SEED TREES (E.P. 935) S.D. ROSS

Preliminary trials conducted in 1981 (E.P. 935.02) disclosed that a number of horticultural spray oils which could possibly be used to enhance the absorption and efficacy of foliar-applied gibberellins (GAs), and to act as anti-evaporants in ULV spraying systems, were phytotoxic to conifers. Several did show promise, and propylene glycol, which was safe at concentrations up to 100% in water on non-actively growing seedlings, was selected for further testing in 1982. However, it too was severely phytotoxic to newly flushed white spruce (E.P. 935.04) and western hemlock (E.P. 935.05) propagules in $GA_{4/7}$ applications properly timed for cone induction. Aqueous-surfactant and ethanolic spray formulations of $GA_{4/7}$ were less phytotoxic, although their efficacy in cone induction has yet to be assessed.

Results from E.P. 935.01 (see 1981/82 Research Review) were confirmed in E.P. 935.06, establishing that although GA_7 is the active flower promotion component of the $GA_{4/7}$ mixture, the two GAs interact synergistically. The commercial fungal-produced $GA_{4/7}$ mixture was no more effective than that prepared from purified GA_4 and GA_7, as would be expected if trace amounts of GA_9 and other GA-like substances in the fungal broth were responsible for the observed synergistic effect. Further, all ratios of GA_4 and GA_7 were equally effective, which is important to know since the ratio in the commercial mixture varies considerably from lot to lot.

Gibberellin A_3 (GA_3) spray applications of 2, 4 and 8 weeks, about period midpoints of 9 July and 6 August, were compared to determine the optimum treatment times for promotion of female and male flowering in western redcedar and yellow-cedar (E.P. 935.03). For yellow-cedar the treatments evidently were started too late for maximum effectiveness. Only the earliest applications, begun on 11 June, promoted seed cones. Pollen cone promotion decreased rapidly with later applications. This was independent of treatment duration. Western redcedar, in contrast, flowered profusely in response to all GA_3 treatments: 25-53% and 7-36% of vegetative apices of individual trees differentiated into pollen and seed cones, respectively, compared to 2.4% and 0.5% for control branches. A 4-week treatment from early June to early July under long day lengths appears to be optimal for promotion of pollen cones. A 4-week treatment from early July to early August under shortening day lengths may be expected to maximize the number of seed cones initiated. However, to ensure full and complete development of the induced seed cones, treatment should be extended to mid-August (i.e. 6 weeks) to bracket not only the period of cone-bud differentiation but also the period of bract and ovule initiation. The promotion of flowering was proportional to the logarithm of the average weekly dosage of GA_3 used over the range 50-200 mg L^{-1} wk^{-1}, and it appeared to make little difference whether this dosage was applied weekly or biweekly at double the hormone concentration. Based on these findings, a new approach to western redcedar seed orchards is recommended, wherein ramets are planted at a very close spacing, using GA_3 applications to induce precocious flowering and crown pruning to maintain trees at a manageable size for treatment and harvesting of cones.

SEED ORCHARD CROWN MANAGEMENT (E.P. 944) S.D. ROSS

Under the favourable growing environment that seed orchards provide, orchard trees rapidly attain a height and size where harvesting of cones becomes very costly. Four long-term studies were initiated in 1982, in collaboration with Silviculture Branch and Western Forest Products, to develop crown pruning techniques that not only provide effective height control, but will possibly also increase yields in Douglas-fir and western hemlock seed orchards. Annual responses of crown height, crown diameter increments and cone production to different severities of top pruning - initiated in still-young orchards of each species, as well as those in which the trees are already approaching a maximum height for easy cone harvesting - will be monitored over the next 5-10 years. Half the trees per treatment in the young Douglas-fir orchard (E.P. 944.03) received gibberellin stem injections in 1982, and the flowering responses are presently being analysed. The hypothesis being tested is that this and other flower-stimulation treatments will be more cost effective on pruned orchard trees as a result both of reduced application costs and the redistribution of rapid height growth into abundant shoots with higher potentials for differentiating cone buds.

HORTICULTURE OF CONTAINERIZED SEED ORCHARD TREES (E.P. 961) A.M. EASTHAM

Container seed orchard research facilities were greatly expanded in 1982 with the erection of three new shelterhouses (one heated), resulting in a combined area of 800 m^2. Overhead irrigation was installed, and the construction of a drip irrigation system and the automation of watering and fertilizing are in progress. Outdoor container beds have been upgraded and the total growing area expanded. Stock inventory was increased and quality has improved, the result of improved cultural practices in the area of pest control, plant nutrition, and water relations. As a result of these improvements, it is now possible to undertake more intensive investigations aimed at optimizing horticultural regimes and environmental conditions for early growth acceleration, cone induction, and seed development.

A long-term study has been initiated to determine the cost-benefit of accelerated growth regimes on tree growth and early flowering (E.P. 961.02). The treatments consist of five growing environments: 1) outdoors, 2) unheated shelterhouse, 3) bottom-heated shelterhouse, 4) heated shelterhouse, and 5) heated shelterhouse plus lights. Within each regime, there are two or three pot sizes.

Drought is one cultural technique used to induce flowering in conifers. Different methods of assessing plant water status were investigated in a growth chamber study to find an operationally practical method of determining when to water the trees (E.P. 961.01). A useable relationship was found between pre-dawn plant water potential and readings from a conductivity type of soil moisture meter. The inexpensive, simple-to-use meters will be used to determine when a tree should be watered during stress treatments in subsequent flower induction studies.

Trees in E.P. 865.02, a study initiated in 1981 to assess the performance of white spruce in fine media in four pot sizes, were grown over the 1982 season and harvested in late fall. Shoot volume, shoot height, and stem diameter were measured and the data are presently being analysed. Physical appearance of the whole tree (shoots and roots) was recorded photographically for representative trees in each treatment.

INVESTIGATION OF SITE EFFECTS ON LODGEPOLE PINE FLOWERING (E.P. 907)
M. CARLSON AND J.E. WEBBER

Procurement of seed inventories for lodgepole pine is not considered to be a problem. However, poor production of male flowering is common among recently grafted clonal stock. Since this is an impediment to the rapid advancement of the lodgepole pine breeding program, techniques to enhance early male production are being sought. This project was designed to: 1) determine site effects on flowering age and intensity in lodgepole pine, and examine trends of response to north-south movement; 2) identify site selection criteria for breeding orchards; and 3) compare the flowering differences between grafts, bareroot seedlings, and accelerated container seedlings.

In the 1981 growing season, bareroot seedlings were grown and clonal grafting done at Red Rock. Accelerated growth stock was produced at the Wilkinson Road Jail greenhouses in large open beds (peat/sand/vermiculite at a ratio of 1:1:1), about 15 cm deep. The root system was box-pruned twice, once after the first 6 months, and also following the second spring flush prior to lifting. Due to greenhouse demolition these accelerated growth trees had to be lifted in June 1982. Trees destined for three interior sites were shippped to Red Rock and transplanted. The remaining stock was transplanted at North Road.

A coastal plantation was located on MacMillan Bloedel land in the Nanaimo River Valley. The site was a flat, uniform, well drained sandy loam. Brush was removed and the site disced. In October 1982 the site was planted with the three stock types (grafts, bareroot, and accelerated) using a completely randomized block design. All trees were planted with black plastic (woven) mulch film to reduce future weeding and competition. The three interior sites will be planted in 1983.

STORAGE CONDITIONS AND VIABILITY TESTING FOR CONIFEROUS POLLEN (E.P. 773)

J.E. WEBBER

Results from a Douglas-fir pollen-bud storage trial (E.P. 773.02) suggest that fresh buds can be stored at +4°C for upwards of 1 week prior to extraction. It is not recommended that buds be stored at any other temperatures (greater than 4°, less than 0°C) or for periods longer than 1 week.

Under the conditions described here for post-harvesting storage of pollen buds, it is assumed that pollen, extracted after the designated bud-storage period (0,2,4,6, and 8 days at 4°C) was neither less mature nor viable compared to the control (no bud storage). These conclusions were based on seed yields from controlled crosses of pollen stored for two years in evacuated containers at -20°C. Seed yield from pollen extracted after 8 days bud storage was not significantly different than yields from pollen extracted immediately after bud picking (0 days storage).

Results from this year's viability tests (E.P. 773.03) were encouraging. Three potentially useful viability assays were tested. Conductivity is a measure of pollen membrane integrity and theoretically should show an inverse relationship to seed yield (higher conductivity values of pollen leachate indicate a greater degree of membrane damage and therefore, lower potential fertility). Germination is an overall measure of pollen viability but in Douglas-fir, defining a germinating pollen grain is difficult. The third viability assay tested was respiration. A pollen lot's ability to consume oxygen under controlled conditions should reflect its overall metabolic status and, therefore, its potential fertility.

In this year's trial, 10 lots of Douglas-fir pollen (stored under various conditions and for different periods of time) were assayed using the three viability tests. Each lot was pollinated on eight separate female parent trees using an undiluted (100%) and diluted (50% dead) mix. Seed yield data were determined for each pollination (filled seeds per cone) and compared to their corresponding viability assay.

A significant regression existed for respiration ($r_{100\%} = 0.66$ at p 0.05%, and $r_{50\%} = 0.88$ at p 0.01%) but not with germination or conductivity. It has been established that Douglas-fir pollen can be diluted up to 50% without significantly reducing seed yield. In this test, the used 50% diluted pollen apparently intensified the effect of viability and gave a better correlation between respiration rate and actual fertility.

SUPPLEMENTAL POLLINATION IN SEED ORCHARDS (E.P. 821) J.E. WEBBER

Western hemlock seed orchards are now producing sufficient seed cone crops to make supplemental pollinations a consideration. Operational production from container seed orchards appears feasible as demonstrated by early results of E.P. 865. Since the pollination mechanism in western hemlock is different from Douglas-fir, it was important to establish optimal time of pollination.

In this trial, five treatment periods were tested, 0, 2, 4, 6, and 8 days beyond bud burst, defined as that stage when the buds, viewed from the tip, had their ovuliferous scales exposed over the entire diameter of the bud.

Fresh pollen was obtained from six clones by moving two ramets of each from an unheated shelterhouse into a heated greenhouse when the pollen buds began swelling. Two ramets each of five clones with heavy seed-cone crops were moved outdoors to slow development. About 10 days later, pollen-cone buds in the heated greenhouse were picked, dried (48 hrs at 30°C) and the pollen extracted. The seed-cone ramets were then returned to the shelterhouse and all pollen-cone buds removed.

At each of the five treatment periods, each cluster of seed-cone buds was pollinated with 0.5 ml (0.2 g) pollen and bagged. Cones were collected in the fall and total seed and total filled seeds determined from X-rays.

Seed yield increased from 12 filled seeds per cone from pollination at bud burst to a maximum of 22 filled seeds per cone from pollination at 8 days. Seed yield results for each treatment period were as follows:

Days Beyond Bud Burst	Filled Seeds per Cone ± SE
0 days	11.8 ± 0.98
2	14.8 1.27
4	18.0 1.66
6	21.6 1.40
8	22.4 1.52

This trial will be repeated next year and isolation bags will be used prior to bud burst. Furthermore, a 12-day period will be considered, to determine if the receptivity period of western hemlock continues beyond the 8-day period suggested here.

MINERAL NUTRITION OF SEED ORCHARD TREES (E.P. 918) R. VAN DEN DRIESSCHE

Soil analyses were completed for the four coastal seed orchards. Results suggested that the Saanich orchard soil contains most nutrients, with Quinsam also being relatively nutrient rich. Snowdon was particularly low in available P and may have inadequate Ca. Koksilah is the most nutrient poor of the four orchards except that it has a relatively high P level.

Foliage collected in October 1982 from coastal Douglas-fir, interior spruce and lodgepole pine seed orchards was analysed and a fertilizer recommendation prepared.

PUBLICATIONS

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SEEDS

Studies continued into the stratification-redry system for improving Abies spp. germination, facilitated by development of a rapid microwave moisture determination method. Pelleting of western redcedar has been tested to the stage where semi-operational trials of machine sowing are planned for the coming year, at an estimated 85% labour cost reduction over hand sowing. A germination vigour test is being evaluated for its ability to predict seed performance under adverse nursery conditions.

IMPROVING SEED PERFORMANCE (E.P. 848) C.L. LEADEM

Seven Amabilis fir lots were chosen from 1982 sowing requests. Approximately 10 000 seedlings per lot received either (1) normal stratification (2°C) at 40% moisture content for one month; or (2) stratification for one month at 40% moisture content, followed by two months stratification after drying to 30% moisture content.

Two new techniques were developed to facilitate operational implementation. A previous difficulty with the redry method was the inability to quickly measure seed moisture, especially during the 6 hour drying period. This problem has been resolved with the development of the microwave oven technique (E.P. 940.01). An experimental rotary tumbler was successfully used as a means of safely and efficiently drying operational quantities of seeds.

Results show that the redry treatment consistently increased germination, but the effects diminished with time. After two weeks controls germinated 1%, whereas redried seeds germinated 17%. However, after six weeks controls and redried seeds germinated 54% and 59%, respectively.

In spite of their similar performance under warm greenhouse conditions, there is evidence that redried seeds outperform controls under low temperatures. The effects of temperature on redried seeds will be examined during the coming year.

MONITORING CONE AND SEED PERFORMANCE (E.P. 874) C.L. LEADEM

E.P. 874.03

Normal laboratory germination tests do not always indicate how seeds will perform under nursery conditions. Better, more accurate methods for determining seed vigour are required. The vigour test to be investigated evaluates the capability of a seed to produce a seedling which will reach a certain stage of development within a standard germination period (Figure 1). According to this vigour class system, high vigour seeds are those which show the maximum development in the shortest time.

Vigour test results will be compared with those obtained from the standard test to see if germination classes can be correlated with standard germination criteria. A second object of the study will be to evaluate how well the vigour test differentiates between seed treatments. Seeds will receive different treatments prior to germination, then will be evaluated by both tests.

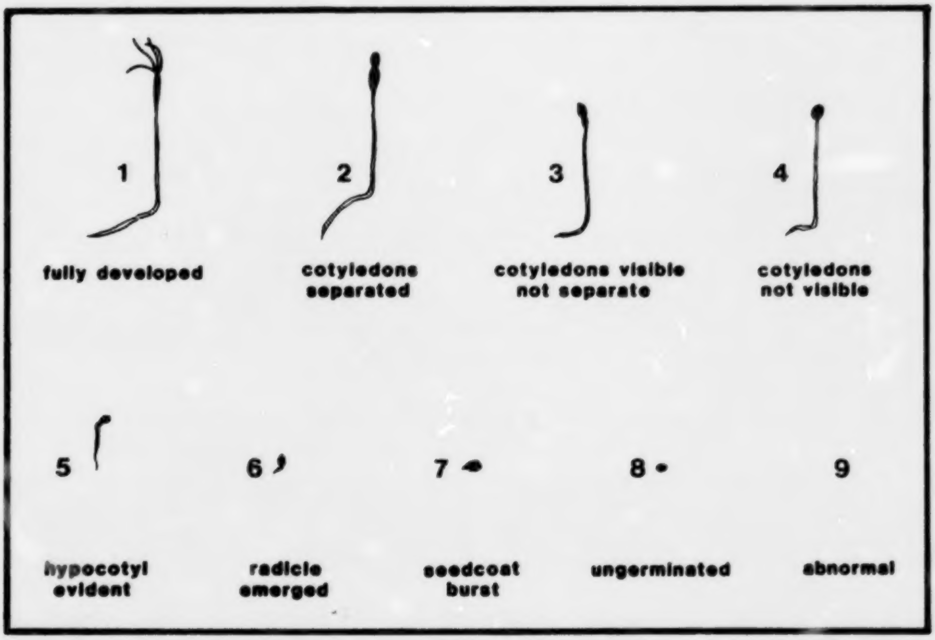
1
fully developed
2
cotyledons separated
3
cotyledons visible not separate
4
cotyledons not visible
5
hypocotyl evident
6
radicle emerged
7
seedcoat burst
8
ungerminated
9
abnormal

Figure 1. Vigour tests are better indicators of nursery performance than standard laboratory tests. How quickly seedlings progress through developmental classes is one way of assessing vigour (E.P. 874.03).

PELLETING TREE SEED TO IMPROVE SOWING PRECISION AND EFFICIENCY (E.P. 909)

C.L. LEADEM

The objective of the study was to determine the effects of pelleting and different misting regimes on germination of three western redcedar seed lots which had been pelleted by Moran Seeds, Salinas, California. The seeds were sown on March 15, covered with at least 1.0 cm of washed sand, then placed on pallets in an unheated poly greenhouse. All treatments were replicated six times.

Results showed that there was no benefit to applying supplemental watering before gritting. Although earlier studies indicated that pellets did not always disintegrate, there appear to be no problems under present cultural practices. Pelleted seeds germinated 86%, whereas unpelleted seeds germinated 87%.

On the basis of present and previous studies, pelleted western redcedar seeds will be sown on a semi-operational basis in spring 1983. Using vacuum drum seeders specially modified for Spencer-Lemaire containers (see Figure 2), 500 000 seedlings will be sown at Koksilah Nursery. In addition to being able to sow more seedlings in less time, labour costs will be reduced by approximately 85%.

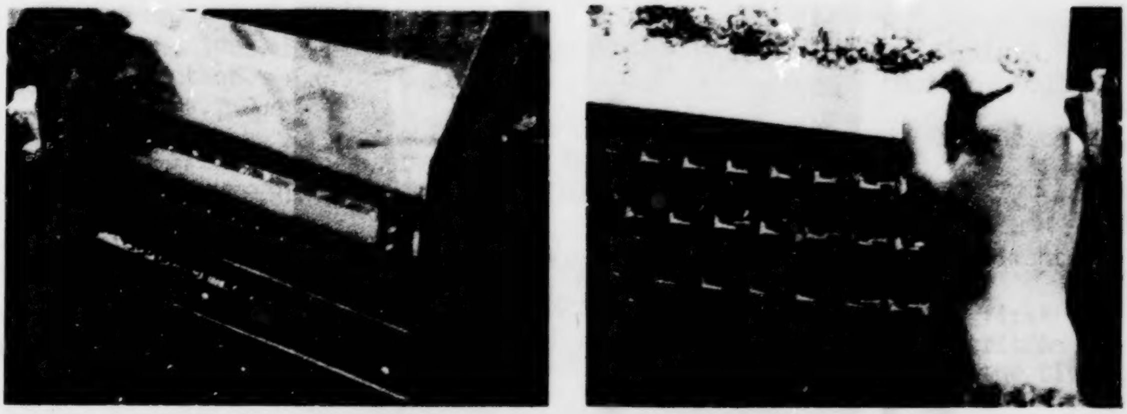

Figure 2. Pelleting western redcedar seeds makes mechanical sowing possible, reducing labour costs by 85%. Pelleted seeds can be sown with a vacuum drum seeder (left) whereas uncoated seeds must be sown by hand (right) (E.P. 909.05).

CONE AND SEED TECHNOLOGY DEVELOPMENT (E.P. 940) C.L. LEADEM

E.P. 940.01

Progress in stratification-redry research (E.P. 848) was hampered due to the lack of a rapid method for measuring seed moisture. Moisture contents were needed within 30 minutes, yet 24 hours are required by the standard oven method.

Using a home microwave oven (Figure 3), moisture contents can be obtained within 3-8 minutes, depending upon the species. It is a simple procedure which requires only a balance and microwave oven. Seeds are placed in paper cups, weighed, then dried for the prescribed time. Seeds are reweighed after drying to calculate the moisture lost.

The technique has been tested on a variety of seeds, including hard-seeded species and those with attached wings. When microwave and convection oven results were compared with the toluene distillation standard, the microwave method was as accurate as the convection oven. In addition, the microwave method is quicker and more economical. However, because of the variable energy distribution within microwave ovens, sample placements must first be determined by a simple calibration procedure.

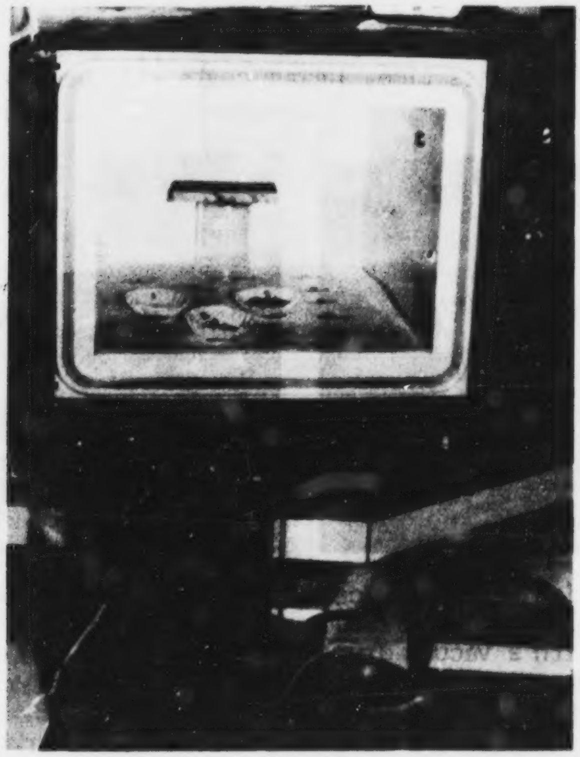

Figure 3. Seed moisture contents can be obtained within 3-8 minutes with a microwave oven (E.P. 940.01).

ACTIVE EXPERIMENTAL PROJECTS

E.P. 835	The effect of soaking seeds on germination of some major B.C. forest trees	C. Leadem
E.P. 838	Quick tests to determine seed quality	C. Leadem
E.P. 843	Seed sizing and sorting	C. Leadem
E.P. 848	Improving seed performance	C. Leadem
E.P. 873	Effect of cone storage on seed viability	C. Leadem
E.P. 874	Monitoring cone and seed performance	C. Leadem
E.P. 909	Pelleting tree seed to improve sowing precision and efficiency	C. Leadem
E.P. 940	Cone and seed technology development	C. Leadem

PUBLICATIONS

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NURSERIES, STOCK QUALITY AND PRE-PLANTING TREATMENTS

Trial planting of Sitka spruce rooted cuttings has followed experiments showing optimum conditions for rooting. Trials with napropamide in combination with prometryne showed 75% reduction in weeding time in first season nursery beds. Studies continued in management of mineral nutrition in nurseries. Fertilization at planting clearly increased growth over the first two seasons but only slow release fertilizer could be safely broadcast. Soluble fertilizers required dibble placement to avoid mortality under dry conditions. Beneficial effects were obtained from properly timed root wrenching of 2+0 Douglas-fir, particularly if combined with increased fertilization, but treatments required careful balance. Seed bed density trials have been extended to successful operational trials of large seeded species with the New Zealand Summit precision seeder. The survival and growth superiority of plug stock of interior spruce, with 4-8 times the root growth capacity of bareroot stock, has been confirmed in additional experiments.

Preliminary investigation into causes of white spruce planting check showed that, after six months of cold dark storage, there was a 22% overall depletion of food reserve carbohydrates, a tripling of photorespiration, and a disruption of the photosynthesis mechanism.

Studies resumed on induction of dormancy and frost hardiness in western hemlock container seedlings.

VEGETATIVE REPRODUCTION IN SPRUCE (E.P. 667) R. VAN DEN DRIESSCHE

Rooted cuttings from hedged trees and tree-form ramets of two clones, together with seedlings of the same seed source, were planted out at Naka Creek in early spring 1982. An initial measurement made in October showed that survival was good and that shoot growth of cuttings from hedges was not significantly different from seedlings, although shoot growth of cuttings from trees was significantly less than growth of seedlings and cuttings from hedges.

Other work has confirmed that ease of rooting in two clones of Sitka spruce increases, according to point of origin, in the order upper crown - less than lower crown - less than hedge. Time at which cuttings are taken during winter also influences ease of rooting, with the late January to early February period giving best results. Periodic removal of cuttings during winter and placement in cold storage, at 2°C, suggested that there is a chilling requirement which must be satisfied to obtain maximum rooting.

Determination of starch, total sugar, glucose, fructose, and sucrose concentrations in stems and needles at cutting showed no general relationship to ease of rooting.

TESTING SELECTIVE HERBICIDES FOR BAREROOT AND CONTAINER NURSERIES (E.P. 693)

R. VAN DEN DRIESSCHE

The pre-emergent herbicide napropamide was tested on Douglas-fir and white spruce at Green Timbers Nursery in Surrey and on Douglas-fir and western redcedar at Koksilah nursery. Napropamide was well tolerated by Douglas-fir up to 8 kg/ha when applied 28 days after germination. Western redcedar did not tolerate napropamide treatment, but its germination was slow and irregular, which may have accounted for the lack of tolerance.

Time required to weed plots treated with 4 kg a.i. napropamide/ha was reduced 77% in September. The experiment also tested the use of prometryne in combination with napropamide and showed that the two herbicides combined could reduce weeding time in 1+0 seed beds over the season as much as 75%.

REQUIREMENTS OF CONIFER SEEDLINGS FOR MINERAL NUTRIENTS (E.P. 640)
R. VAN DEN DRIESSCHE

Previous work (E.P. 640.77) comparing slow release fertilizers with ammonium phosphate (11-55-0) and ammonium sulphate (21-0-0) showed that soluble fertilizers produced larger seedlings. Clearly the frequency with which soluble fertilizers are applied has a marked effect on growth and this is now under study at the Surrey nursery (a sandy soil) and at North Road Laboratory (a loam). Chemical analysis showed that soil mineral N levels were positively related to severity of Fusarium damage to 1+0 Douglas-fir stands at North Road. Nitrogen fertilization of 1+0 Douglas-fir must be carefully controlled to avoid Fusarium damage, particularly on heavy soils.

During the last three summers interior spruce 2+0 and transplants at the Surrey nursery have been showing yellowing and browning of needles at the shoot apex. The symptoms are usually worse on transplants and appear in about July, roughly when extension growth is completed and buds are forming. A potassium fertilization experiment (E.P. 640.82) showed that the symptoms were reduced by high levels of K, but not eliminated. In addition, tissue analysis showed that although shoots showing the symptoms generally had K concentrations lower than green shoots, their levels (0.4-0.6% K) were probably well above the deficiency level (0.3% K). The current hypothesis is that a micronutrient is involved in development of the symptoms, and this is to be tested.

Autumn measurement and chemical analysis of 1+0 seedling samples were conducted as usual. This year samples were received from 10 nurseries, including the first industrial bareroot nursery (Grandview). Samples from several nurseries suggested that Ca levels were becoming low and additions of limestone were recommended.

NURSERY EXPERIMENTS WITH MINERAL NUTRIENTS (E.P. 753) R. VAN DEN DRIESSCHE

An experiment was set up to test the effectiveness of four proprietary fertilizers, two of them at two different concentrations, for supply of nutrients to white spruce and lodgepole pine grown in styro containers (PSB 211). All fertilizers were supplied with and without ferrous sulphate. Preliminary analysis indicates that, provided ferrous sulphate is supplied, all the fertilizers produced similar growth responses. However, the iron requirement of spruce and pine seedlings growing in containers is quite high and is not satisfied by all proprietary fertilizers.

THE EFFECTS OF UNDERCUTTING AND WRENCHING IN THE NURSERY ON SEEDLING QUALITY (E.P. 846) R. VAN DEN DRIESSCHE

The effects of existing nursery undercutting and wrenching procedures on outplanting performance of Douglas-fir stock have been examined. Wrenching treatments were applied to 2+0 Douglas-fir seedlings, growing in a loamy sand, for different periods between 15 May and 11 September as follows: (1) unwrenched, (2) early summer, (3) mid summer, (4) late summer, and (5) throughout summer. Three different levels of fertilization were applied to each wrenching treatment, and seedlings were lifted for storage at 2°C in October and December. Stored trees and freshly lifted trees were planted at 700 m elevation on 3 March. Wrenching increased root dry weight, particularly when additional fertilizer was applied, but had no measurable effect on cold hardiness or root growth capacity. Nevertheless late summer wrenching increased survival 5% and 7% above control one and two years after planting, under conditions in which average survival was only 47% after one year. Wrenching had little subsequent effect on new shoot growth of planted trees during two years after planting. However, late summer wrenched trees showed significantly more new shoot growth than trees wrenched throughout the summer.

Increasing fertilization reduced cold hardiness and survival of cold stored trees, but increased root growth capacity. Cold hardiness measured by electrical impedance was correlated with survival of cold stored trees after planting (r^2=0.82). Root growth capacity, averaged over all fertilizer levels, was closely correlated with survival of stored and freshly lifted trees (r^2=0.93). Foliar nutrient concentrations were reduced by wrenching, but fertilization increased nutrient reserves within the seedling.

NURSERY SEED BED DENSITY AND SEEDLING SPACING (E.P. 786) R. VAN DEN DRIESSCHE

Favourable results from reduced seed bed density trials led to Silviculture Branch purchase of a precision seeder designed and built for use in forest nurseries by Summit Engineering in New Zealand. The machine obtained was set up to sow Douglas-fir seed and worked well with this species. It also sowed lodgepole pine and Sitka spruce seed quite successfully. Operation was tested at five spacings, 1.9 cm to 10.6 cm, at Surrey and the Campbell River Nursery. Although seed placement was accurate, spacing in 1+0 stands in August was surprisingly irregular, partly due to incomplete seed germination (about 80% germination for most seed lots) and perhaps partly due to other mortality.

A small single row precision seeder (Fähse Miniair) has been obtained from West Germany and will be tested. It may be more suitable for sowing small white spruce seed.

Douglas-fir 2+0 seedlings grown at four spacings, 1+1 transplants grown in the same beds, and 313 styro plugs are to be planted to compare performance of spaced trees with performance of transplants and plugs.

COLD STORAGE PHYSIOLOGY OF CONIFER SEEDLINGS (E.P. 737) W.D. BINDER

A preliminary study was initiated in the spring of 1982 to investigate the hypothesis that long-term, cold, dark storage of interior spruce may alter important physiological parameters in a degradative way, contributing to reduced seedling vigour on outplanting. Data from two seedlots indicate that during 6 months' cold (-2°C) dark storage, total food reserve carbohydrates decreased approximately 28%, 25%, and 14% in stems, roots, and needles respectively. A whole seedling depletion of between 21 and 23% was apparent. This decrease was in the soluble sugar component which was reduced by approximately 42%, 58%, and 15% in stems, roots, and needles respectively. Part of the sugar decrease may be due to conversion to starch, which doubled in roots and needles and appeared to be four times higher in stems.

Carbohydrate food reserves are involved to varying degrees in most if not all physiological processes and, therefore, can be viewed as a good indicator of overall tree nutrition and planting stock quality. Evidence in the literature suggests that food reserves can be depleted by continued respiration during cold storage, perhaps to critical threshold levels causing physiological weakening, leading to reduced growth or mortality on outplanting. The present preliminary study suggested such problems could be encountered with interior spruce. Furthermore, the data indicated that roots contained over 80% of the reserve starch in the seedlings. This could account for a significant loss in food reserves in that as much as 40% of the root system is pruned prior to storage. At present there is no explanation for the apparently anomalous observation for the starch build-up. The conversion from sugars to starch is very energy demanding. Moreover, it is usually observed that carbohydrates are initially stored as starch and converted to simple sugars under cold conditions. Increased cellular sugar concentration is a requirement for attainment of cold hardiness. There thus exists the possibility that reduction of soluble sugars during storage could result in freezing damage at the cellular level.

Other degradative processes may also occur with long, cold, dark storage. Chlorophyll pigment concentration was reduced by 6.0% in one seedlot. Preliminary experiments showed rates of photosynthesis were very low for at least 5 days after removal from storage, compared to normal conifer rates. Variable fluorescence (Kautsky) curves from needles were indicative of disrupted photosynthetic membrane structure and composition. Dark respiration rates were equal or higher than those generally reported and CO_2 compensation points were almost triple to reported values. Data from seedlings transferred to +2°C (from -2°C) for 4 - 5 weeks suggested that a degree of recovery of the photosynthetic system was taking place. Once shoot flushing occurred the photosynthesis system appeared to be very sensitive to temperature and humidity. The implications of a damaged photosynthetic system on planting are obvious. Proper handling of seedlings from freezer storage may allow reactivation and/or repair of the photosynthetic system.

New studies are underway to closely examine the effects of cold storage duration on a number of physiological parameters. As well, the role of root pruning and different storage temperature regimes on seedling vigour and food reserves are under investigation.

INDUCTION OF DORMANCY AND FROST HARDINESS IN WESTERN HEMLOCK PLANTING STOCK (E.P. 764) W.D. BINDER

Three experiments at two different nurseries were conducted in summer and fall 1982 to monitor western hemlock seedling dormancy induction, frost hardiness, and growth response to chemical growth retardants. Although analysis is incomplete at this time, the following trends are evident:

Frost hardiness of western hemlock may be increased by applying DMSO at less than 3.0% (0.1% seems optimum). Concentrations higher than 3.0% were phytotoxic. Ethrel also increased frost resistance, 100 ppm being more effective than 500 ppm and 1000 ppm. Ethrel and DMSO in combination did not act synergistically, instead the affect appeared to be antagonistic. Both DMSO and ethrel retarded bud flushing for approximately one week when treated seedlings were placed in permissive growth conditions. Root growth capacity on lifting was decreased by approximately 50% when sprayed with 3.0% DMSO and 100% by a combination of 500 or 1000 ppm ethrel with 3.0% DMSO. The effect of chemical sprays on shoot length, root collar, and root weight and volume await statistical analysis as does use of chemical sprays in association with a blackout system.

NEEDLE CAST FOLLOWING GREENHOUSE GROWING OF WESTERN HEMLOCK (E.P. 958)
W.D. BINDER

The experiment was initiated on 30 August, using a polyethylene covered greenhouse seedling source. Seedlings were grown under 25%, 50%, and 75% shade, under polyethylene, or open to 18 October, and then harvested for measurements. Data analysis is incomplete but the following trends are evident: (1) Root volume and root fresh weight trends indicate that polyethylene and open grown seedlings gained the most root volume and fresh weight, while increased shading decreased both root volume and fresh weight compared to the control; and (2) Root collar diameter of polyethylene grown seedlings may be higher. There was no apparent difference in shoot length between open, polyethylene, 25%, 50%, and 75% shade and original greenhouse (control) grown treatments. No needle cast was evident in any of the treatments during the period of monitoring or after fall planting in the field. Chlorophyll analysis on 20 September, 1982 indicates that total chlorophyll content was highest in the 75% shade treatment and lowest in the open grown treatment. The trend of highest to lowest was as follows: 1) 75% shade 2) 50% shade 3) 25% shade 4) polyethelene 5) original greenhouse (control) 6) open grown.

The experiment indicates that western hemlock container seedlings are sensitive to nursery light conditioning. At higher light intensities growth appears to be shifted in favour of the root. Although such a growth shift could be expected to affect top growth this was not apparent. Had the experiment been started earlier in the growing season such a response could perhaps have been noted. Although no needle cast was observed, the higher chlorophyll concentrations of shade grown seedlings at least suggests that needle burn could be a potential problem on high light intensity planting sites. Furthermore, the lower green pigment concentrations observed at higher light intensities suggests that the seedlings can potentially be conditioned to such sites in the nursery.

EARLY GROWTH AND SURVIVAL OF INTERIOR SPRUCE STOCK TYPES (E.P. 859)

R. VAN DEN DRIESSCHE

Results from E.P. 859.01 supported the general contention that plug stock survived and grew better than bareroot stock. Thirteen different stock types were grown using one seed lot: Many of these stock types were also grown using a second seed lot and some stock was raised at the Surrey nursery and some at Red Rock Nursery. Measurement of the trees one season after planting showed the ranking in order of performance, which was determined on the basis of survival, shoot growth, and shoot length relative growth rate, was (1) PSB 415 (2) PSB 211 (3) PSB 312 (4) 2+2 or 1 1/2+1/2 transplants followed by bareroot stock. Transplanted container stock and bareroot seedling stock generally performed very poorly, but bareroot stock from Red Rock showed somewhat better performance than bareroot stock from Surrey.

The superiority of plug stock was also confirmed in results from E.P. 859.03. At time of planting root growth capacity (RGC) of PSB 415 stock was eight times greater, and RGC of PSB 211 stock was four times greater than that of bareroot stock. Neither undercutting nor spacing in the beds had any measurable effect on RGC of bareroot stock when measured at the time of planting. Spacing to 5 cm produced 2+0 seedlings which were at least as large as 1 1/2+1/2 transplants and which had equivalent RGC values. Transplanting PSB 211 styro plugs produces transplants which are substantially larger than stock obtained from bareroot sowing, but of no greater RGC.

Results from E.P. 859.04 were reported in the Research Review for 1982. Autumn and spring sowings of bareroot white spruce is being compared with white spruce germinated in peat blocks (E.P. 859.08).

IMPROVING EARLY GROWTH AFTER OUTPLANTING (E.P. 946) R.VAN DEN DRIESSCHE

Coastal Douglas-fir trees, from E.P. 946.02, fertilized at planting in 1981 with different amounts of two types of slow release fertilizer, were remeasured in autumn 1982. The highest level of fertilization, 33.6 g N/tree, increased total height 17% and new shoot growth 70%. Survival remained high and was unaffected by method of application (broadcasting versus dibble placement) but was slightly, and significantly, higher for Agriform (92%) than for Osmocote (89%). New shoot growth in 1982 was actually less than in 1981, presumably due to unusually dry weather which occurred during May and June.

Two additional experiments were conducted in 1982 to test the effect of levels and methods of placement of slow release and soluble fertilizers. One experiment (E.P. 946.03) was planted with bareroot Douglas-fir at Campbell River and the other with white spruce container stock (PSB 211) in the Spanish Lakes area of the Cariboo Forest Region.

The Douglas-fir experiment was planted in March. From 1 May to 25 June there was no significant precipitation and the maximum June temperature was 36.9°C. Mortality due to these conditions was clearly severe by July. The severity of the dry weather demonstrated that only the slow release Agriform tablets can safely be "broadcast" on the surface. Placement of diammonium phosphate, ammonium sulphate, and triple superphosphate in holes 15 cm from the tree resulted in no increase in mortality compared to the control, but broadcasting did increase mortality. Broadcast ammonium sulphate resulted in 2% survival, whereas injected ammonium sulphate resulted in 40% survival. Control plot survival was 45%.

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ACTIVE EXPERIMENTAL PROJECTS

E.P. 746	Physiological aspects of nursery production and field establishment of lodgepole pine, white spruce and interior Douglas-fir.	A.N. Burdett
E.P. 858	New methods for the production of forest planting stock.	A.N. Burdett
E.P. 928	Quality control in the production of nursery planting stock.	A.N. Burdett

ANALYTICAL LABORATORY

ANALYTICAL LABORATORY SERVICES A.M.E. VALLANCE

The number of soil, plant, and miscellaneous samples received in 1982/83 increased by 41, 49 and 810% respectively, over numbers submitted in the previous fiscal year. This information, along with type of analyses, is tabulated below. This increased demand for services was due not only to assumption of analyses for the ecological classification program, but as well from increases of all previous sources.

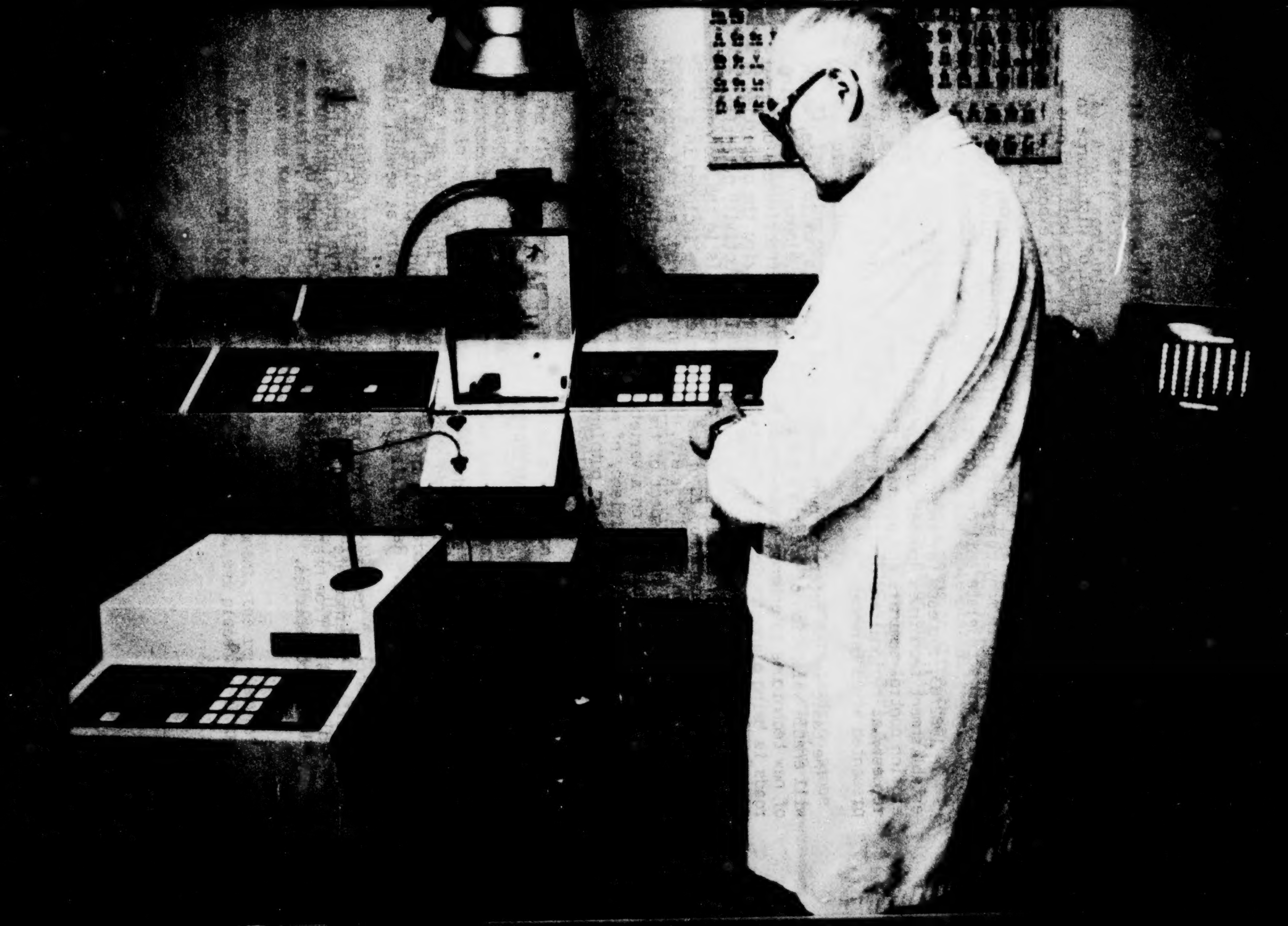
Reduction in the backlog of analysed samples suffered as a result of the hiring freeze and subsequent loss of the chemistry co-op student program position. However, greatly increased future efficiency is anticipated from the installation of a Varian Model 975 fully automated atomic absorption spectrophotometer in March 1983, the last month of the fiscal year.

(see p.29)

Table 1. Analytical laboratory samples received and processed

	1981-82	1982-83
Soil Samples		
Submitted	858	1209
(% processed within fiscal year)	(100)	(55)
Analysed		
Routine analysis, macronutrients	709	339
Micronutrients general	58	6
pH and conductivity only	149	311
Texture	213	43
Sieve fractions	78	0
Aluminum and iron	40	54
Boron	0	10
Plant Samples		
Submitted	1960	2925
(% processed within fiscal year)	(34)	(28)
Analysed (included backlog)		
Macronutrients	2675	2493
Micronutrients general	377	319
Sulphur	190	193
Boron	184	65
Aluminum	163	0
Molybdenum	5	10
Miscellaneous Samples*		
Submitted	69	559
(% processed within fiscal year)	(100)	(90)
Analysed	69	504

*Miscellaneous samples include growing media components, nutrient solutions, fertilizers, samples for carbohydrate and chlorophyll, and other special analyses.



SILVICULTURE

H.J. Benskin, Manager

SITE PROTECTION AND REHABILITATION

Timber harvesting activities can cause a great deal of disturbance to forest soils. The loss, removal or destruction of surface soil horizons by excessive erosion, scarification or burning results in the exposure of less-productive sub-surface soil material. Whether the loss of important surface soil horizons is from man-caused or natural disturbance, vegetation establishment can in many cases control surface erosion, improve soil mass stability and accelerate soil development and recovery of productive capacity.

In 1982/83, requests for technical advice and consultation on vegetation establishment techniques and methodology continued to increase. Numerous erosion control seminars and practical field demonstrations were held, on request, at regional and district levels. Several technical papers were presented at conferences.

The basic set of reference hydroseeding test plots is now in place, which will enable validation of interim prescriptions. The development and testing of new techniques to enhance grass-legume revegetation effectiveness on forest roads is being planned. Research directed at characterizing the properties of severely disturbed sites and recovery of biological productivity potential is receiving more emphasis, now that the hydroseeding work is in the technology transfer phase. Basic data for 20 of the 50 species to be included in a native shrub propagation manual for B.C. have been obtained, and one more year of work should conclude this aspect of the project. Outplanting trials are concurrently being established on a variety of disturbed soil habitats, in order to test the relative efficiency of native shrubs in soil stabilization and rehabilitation, and to develop outplanting prescriptions for field use in the future.

HYDROSEEDING LOGGING ROADS FOR STABILIZATION AND RESOURCE PROTECTION

(E.P. 818) S.G.J. HOMOKY

The 1982 assessment of established test sites indicated that:

1) Percent slope cover remained stable attaining at least 70% at most sites. Some dry locations in the interior support improving but inadequate cover. Refertilization becomes necessary at several sites in 1979.
2) Dominance of red fescue, redtop and two clover species increased, as well as intermediate wheat grass on dry sites. Rye grass practically disappeared from nearly all sites, and is being replaced by indigenous species.

3) Road-side surface erosion only occurred at Hasler Creek, south of Chetwynd.
4) Annual monitoring of most test sites can be terminated, but periodic assessments at two or three year intervals is needed to observe the colonization of treated slopes by native species. Annual assessments of poorly performing dry sites will be continued.

Expansion of the erosion control testing program to enhance the effectiveness of the grass-legume revegetation technique is now in the planning phase. Three areas of investigation are contemplated:

1) The applicability of surface netting as a means to strengthen the soil binding potential of established vegetation and its cost-effectiveness.
2) Suitability of seed mixes and their application either early or late in the growing season for the problematic BWBSc and BWBSd biogeoclimatic subzones.
3) Improving procedures for forest road layout to ensure roadside slope stability, and better vegetative cover establishment for erosion control and stream protection.

Technical advice and consultation was provided for personnel at the Prince George regional office and in Dawson Creek and Fort St. John Forest Districts. Subjects included revegetation techniques, plant selection, measures to prevent mass soil erosion, and associated logistical matters. One lecture series was given at the University of Victoria under the Continuing Professional Education Program.

THE REHABILITATION OF SEVERELY DISTURBED FOREST LAND (E.P. 834) W.W. CARR

The first project component, control of erosion through vegetation management, ran concurrently with E.P. 818. Research into erosion control methodology was expanded. Comparative testing of three soil binders for use in hydroseeding began. Basic plans for the conversion of forest fire tanks for use in hydroseeding are now available. A new helicopter hydroseeding system was successfully tested. The system, utilizing a chemical suspension agent and a conventional seeding bucket, proved to be cost-effective in slurry application.

Technology transfer at the operational level gained momentum. Four training seminars were presented in Nelson, Cranbrook, Smithers, and Vancouver to approximately 100 MOF regional and district staff. Under Research Branch supervision, several district-level erosion control programs were begun in the Nelson and Kamloops Forest Regions.

Research progress on the second project component, the recovery of productive capability on severely disturbed sites, was presented at the Soil

Degradation Workshop (Agriculture Canada) and at the B.C. Mining Reclamation Conference (B.C. Ministry of Mining and Petroleum Resources). Sixth-year remeasurement results of the Koksilah trial indicated a positive response in foliar nitrogen content and seedling growth on degraded soil due to legume-grass presence: findings were presented to the Canadian Soil Science Society. Preliminary results on the use of legumes in landing rehabilitation in Vanderhoof are promising.

Co-operation with other land management agencies involved in erosion control was stressed. A review of watershed rehabilitation options for the Queen Charlotte Islands was prepared for the Fish-Forestry Interaction Program. Co-operative shrub planting trials for erosion control and vegetation management were initiated with B.C. Hydro, Pacific Natural Gas Ltd., and MacMillan Bloedel Ltd. Assistance in the establishment of alternative browse research plots was provided to B.C. Forest Products Ltd. - Crofton Division, for studies of vertebrate damage to conifer regeneration.

THE PROPAGATION AND ESTABLISHMENT OF TREE AND SHRUB SPECIES FOR EROSION CONTROL (E.P. 863) C.J. MARCHANT

Basic data for 20 of the 50 species to be included in a native shrub propagation manual have now been obtained, and experimental trials are on hand for providing most remaining data. The level of shrub production from nursery propagation trials reached approximately 20000, and a large inventory of growing-on or outplant-ready stock will be available for field trials in coastal and interior regions during 1983/84.

A further attempt to reduce deer browse impact on outplanting trials in the Queen Charlotte Islands was made by establishing outplant test sites on two large slide areas using a total of 2600 plants and 12 species.

Co-operators in shrub outplanting trials included: B.C. Fish and Wildlife Branch, B.C. Hydro, West Coast Transmission, MacMillan Bloedel Ltd., B.C. Forest Products Ltd., Crestbrook Forest Industries Ltd., Chilliwack Forest District, Nelson regional office, B.C. Ministry of Highways, and Municipality of North Vancouver.

Those field trials which could be assessed in 1982 showed good shrub survival and growth a few months after planting.

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ACTIVE EXPERIMENTAL PROJECTS

E.P. 777	Rehabilitation of landings and skid trails in the Cariboo Forest Region	A. Vyse
E.P. 818	Hydroseeding logging roads for stabilization and resource protection	S.G.J. Homoky
E.P. 834	Development of vegetation establishment methodologies for use in surface erosion control and site rehabilitation	W.W. Carr
E.P. 863	The propagation and establishment of tree and shrub species for erosion control	C.J. Marchant

FOREST REGENERATION

Activities in forest regeneration research continued to expand in response to the Ministry's emphasis on meeting basic silvicultural goals and the associated need for effective crop establishment methods. Ongoing measurement and maintenance commitments for established projects were successfully accomplished during the field season. Concurrently, new work focussed on co-operative operational trials, technology transfer, and the planning of process-oriented approaches for studying regeneration performance problems.

The development of vegetation management techniques for coastal alluvial sites in the Prince Rupert Forest Region and for sub-boreal and boreal spruce sites in the Prince George Forest Region received much attention during 1982/83. Seven new studies were initiated, encompassing a wide range of treatments: herbicides, mechanical site preparation, large planting stock, and seeding with lesser vegetation. Trials with prescribed fire are planned in the Prince Rupert Forest Region during 1983. In the Cariboo, Kamloops, and Nelson Forest Regions new planting studies were also established to investigate factors such as species choice, stock type, timing of planting, effect of fertilization at time of planting and nursery treatment. The collection of regeneration height growth data continued in the Nelson and Kamloops Forest Region to assist in the development of regeneration performance standards. In the Vancouver Forest Region, work began on developing preliminary guidelines for operational planting of noble fir and for fall planting. An interdisciplinary team of Research Branch scientists was established to plan preliminary field investigations of post-planting spruce ecophysiology in the northern interior during 1983/84.

PAULOWNIA PLANTING TRIAL (E.P. 500) C.L. LEADEM

Paulownia fortuneii is a fast-growing tree native to mild regions of China. It is a versatile hardwood with a high growth rate and is purported to produce as much as 60 m^3/ha/annum. In June 1980 about 40-100 seedlings per site were planted at Port Renfrew, Carnation Creek, and Victoria in order to evaluate their growth and survival.

Results of the trial demonstrated that *P. fortuneii* is not a suitable plantation species for British Columbia. The selected sites were very moderate because *P. fortuneii* is known to be hardy only to -6°C, yet none of the trees survived longer than 18 months. It is possible that *P. fortuneii* might survive if grown under sheltered conditions until well established, but no further investigations of this species are planned.

HIGH ELEVATION SPECIES AND STOCK TYPE TRIALS (E.P. 759) J.T. ARNOTT AND F.T. PENDL

The second phase of this cooperative research project between the CFS Pacific Forest Research Centre and MOF Research Branch was initiated in the fall 1978. Its objective is to identify which of three stock types - 1+0 plug (PSB211), 1+1 plug transplants (PSB211+1) and 1+1 bareroot - is preferable for outplanting in the spring and fall in two of the high elevation biogeoclimatic subzones in the Vancouver Forest Region. Six tree species were outplanted in montane areas of the Wetter Maritime Coastal Western Hemlock subzone (CWHb) and four in the Maritime Forested Mountain Hemlock subzone (MHa). Soils on the test areas were predominantly medium textured, Orthic and Lithic Humo-Ferric Podzols. The soil nutrient regime was in the mesotrophic to permesotrophic range; soil moisture regimes were mesic to subhygric. Interim results presented here are drawn from the fall 1978 to spring 1979 outplantings at Quatchka Creek, Garbage Creek and Guyline Road (CWHb); and at Meade Creek, Mount Arrowsmith and Guyline Road (MHa).

Average third-year percent survival data for the CWHb trials are summarized in Table 1. The main effects of species, planting season and stock types were all highly significant (p=.001). Multiple range tests of the main effects indicated the following:

1) Survival of western white pine was significantly superior to all other species (p=.01).

2) Plug and plug transplants yielded significantly (p=.01) higher survival rates than bareroot stock.

3) Spring planting gave significantly higher (p=.01) survival results than fall planting.

There were significant interactions of species and stock type (p=.05), species and planting season (p=.01), and planting season and stock type (p=.001). Most notable in the latter were the low survival rates obtained from fall planted bareroot western hemlock, amabilis fir and noble fir.

In the CWHb subzone, the tallest species after three years was western hemlock (72 cm) followed by western redcedar (69 cm), Douglas-fir (57 cm), noble fir (44 cm), western white pine (41 cm) and amabilis fir (29 cm). Mean annual height growth of each species in the third year after planting had the same ranking: western hemlock (24 cm/yr); western redcedar, Douglas-fir, and noble fir (all at 18 cm/yr); western white pine (13 cm/yr); and amabilis fir (10 cm/yr). Planting season had no significant effect on seedling growth. Stock type had a highly significant effect (p=.001) on seedling height after three years with plug transplants producing the tallest seedlings followed by bareroot and plug stock.

Third-year percent survival data from the companion set of trials in the MHa subzone are summarized in Table 2. The analyses of variance indicated highly significant (p=.001) differences between species and stock types; planting season differences were only significant at the 5% level. Multiple range tests indicated the following:

1. Survival of mountain hemlock and yellow-cedar were significantly greater than both amabilis and noble fir (p=.01).

2. As in the CWHb trials, survival of plug and plug transplant stock were significantly greater than bareroot stock (p=.01).

3. Interaction of planting season and species was highly significant (p=.001): noble fir achieved best survival from spring planting, yellow-cedar from fall planting, and mountain hemlock yielded similar survival rates from both planting seasons.

In the MHa subzone, the tallest species after three years was yellow-cedar (51 cm), followed by mountain hemlock (42 cm), noble fir (37 cm) and amabilis fir (25 cm). However, in the third year after planting, noble fir was the fastest growing species with a mean annual height growth of 14 cm/yr followed by yellow-cedar and mountain hemlock at 11 cm/yr. As in the CWHb subzone, amabilis fir had the slowest growth rate at 8 cm/yr. There was a highly significant (p=.001) interaction between species and the mean average seedling heights obtained from the three stock types tested.

Table 2. Third year percent survival of six species outplanted as three stock types, over two planting seasons in the CWHb subzone of the Vancouver Forest Region

SPECIES	PLANTING SEASON	STOCK TYPES		
		PLUG	PLUG TRANSPLANT	BAREROOT
Douglas-fir	Fall	88	84	81
	Spring	92	96	93
Western hemlock	Fall	82	86	58
	Spring	89	97	92
Western white pine	Fall	98	98	96
	Spring	98	97	98
Western redcedar	Fall	81	91	81
	Spring	89	91	86
Amabilis fir	Fall	88	89	73
	Spring	87	94	88
Noble fir	Fall	87	83	72
	Spring	94	97	92

Table 3. Third-year percent survival of four species outplanted as three stock types over two planting seasons in the MHa subzone of the Vancouver Forest Region

SPECIES	PLANTING SEASON	STOCK TYPES PLUG	PLUG TRANSPLANT	BAREROOT
Mountain hemlock	Fall	93	96	94
	Spring	94	96	94
Yellow-cedar	Fall	97	97	95
	Spring	95	85	84
Amabilis fir	Fall	85	87	82
	Spring	92	93	88
Noble fir	Fall	90	80	71
	Spring	94	93	91

DEVELOPMENT OF REFORESTATION METHODS FOR AVALANCHE CONTROL (E.P. 781.02)
C.F. THOMPSON

The largest collection of whitebark pine cones to date was made on Baker Mountain. Cone bearing branches were cut off in early September before the onset of bird predation. The branches were stored outside at valley bottom with their cut ends in water until late November, when the cones were picked and the seeds extracted. Cutting tests showed that 85% of the seeds were maturing satisfactorily, with an average of 78% of the embryo cavity filled. This compares with 75% and 30% in the 1981 collection. The seeds are now being tested for dormancy and germination at North Road Laboratory.

A very light cone crop of alpine larch was completely destroyed by late frost. No cones or seeds were collected. No pine cones are anticipated in 1983, and an alpine larch crop is uncertain.

REGENERATION PERFORMANCE ASSESSMENT (E.P. 790.02) M.B. CLARK

The purpose of this study is to collect information on regeneration growth performance and to facilitate development of growth standards for biogeoclimatic subzones and associations. The performance of operational plantations and natural regeneration may then be evaluated with respect to these standards.

An additional 69 plantations were sampled in 1982. Twenty-nine plantations were rejected because of unacceptable survival or damage which inhibited growth for more than one year. The additional samples were added to previous data and revised standards plotted.

The present data base contains minimal data on growth of natural regeneration or on any regeneration within the dry subzones of the Interior Douglas-fir and Ponderosa Pine - Bunchgrass Biogeoclimatic Zones.

PLANTATION PERFORMANCE ASSESSMENT IN THE NELSON FOREST REGION (E.P. 802) C.F. THOMPSON

First approximation plantation performance standards for spruce, based on surveys of 157 plantations in the Nelson Forest Region, are now available. The standards were prepared by stocktype "classes" within biogeoclimatic subzone groups. Based on the present data base, the three stocktype classes recognized are plugs, 2+0 bareroots and 2+1 transplants and 2+0 mudpacks. The two biogeoclimatic subzone groups are: Interior Cedar - Hemlock (ICH) subzones a1, a2 and b and Montane Spruce (MS) a, and Engelmann Spruce - Subalpine Fir (ESSF) subzones a and c.

TREE SPECIES TRIAL IN THE QUEEN CHARLOTTE ISLANDS (E.P. 814) D. COATES AND J. POLLACK

This co-operative project with Western Forest Products Ltd. was established in 1978. The principal objectives of the project were to:

1. determine the best species or species mix among Sitka spruce, western hemlock and western redcedar for planting on the slopes of Sewell Inlet and Lyell Island; and
2. determine the effect of deer browsing on the growth of the three species.

The average performance after five growing seasons at the two locations is shown in Table 4:

Table 4. Height and survival of spruce, hemlock and cedar by location and guarding for E.P. 814, Queen Charlotte Islands

LOCATION	SPECIES					
	SPRUCE*		HEMLOCK		CEDAR	
	Height (cm)	Survival (%)	Height (cm)	Survival (%)	Height (cm)	Survival (%)
SEWELL INLET:						
Guarded	-	-	122.1	49.5	74.8	78.7
Unguarded	120.6	83.3	105.1	69.4	26.1	52.9
LYELL ISLAND:						
Guarded	-	-	102.2	51.7	69.1	69.6
Unguarded	96.6	84.8	87.2	56.1	28.7	49.2

* All guards were removed from the spruce during the fall of 1979 assessment.

The major trends from the fifth-year assessment are:

1. deer browsing has a significant effect on both survival and height growth of western redcedar.
2. deer browsing is equal on guarded and unguarded western hemlock but guarded hemlock shows superior height growth, indicating that guarding helped protect the leaders.
3. growth performance is superior for Sitka spruce and western hemlock at the Sewell Inlet location. Western redcedar shows minimal difference between locations.
4. species performance does not appear to differ between mixed or pure plots.

The fifth-year growing season evaluation of the project will be available in late 1983.

THE EFFECT OF FELLER-BUNCHER/GRAPPLE-SKIDDER LOGGING ON LODGEPOLE PINE CONE DISTRIBUTION AND REGENERATION (E.P. 820) M.B. CLARK

The objective of this study is to monitor the effectiveness of natural lodgepole pine regeneration after feller-buncher/grapple-skidder logging. By 1982, four to five years following disturbance, regeneration on at least 12 of the 16 areas was sufficient to satisfy minimum satisfactory stocking levels.

Additional data collection on feller-buncher/grapple-skidder areas will be necessary to satisfy recently revised Ministry standards for minimum numbers of seedlings, seedling distribution and growth.

EFFECT OF PLANTING DELAY AFTER BURNING, SEASON OF PLANTING AND METHOD OF SEEDLING HANDLING ON GROWTH AND SURVIVAL OF INTERIOR SPRUCE (E.P. 859.06)

A. VYSE

Excellent early growth was observed in two experimental plantations of interior spruce established in the fall immediately following broadcast burning. Subsequently, an experiment was established to compare the effect of planting in the fall or spring following burning with planting in either season one or two years following burning. In the fall of 1980, pairs of fresh and one- or two-year burn sites were selected at seven locations in the Cariboo Forest Region. PSB 211 interior spruce of local seedlots was planted the same fall and in the following spring. Half of the seedlings were planted with a minimum of disturbance by extracting them from styroblocks on site; the remainder were subject to normal nursery handling and storage procedures.

Data analysis following two years of growth shows that, in the first year, season of planting and site had a significant effect on height growth. Spring planting was superior to fall planting on five of the seven pairs of sites, with a maximum difference on any one site of 4 cm increment (Figure 4). In the second season the site effect continued but the effect of season had disappeared. It was replaced by a strong effect of planting immediately following burning, with a maximum difference at one location of 9 cm increment. The largest difference in the total height between spring planting following a fresh burn and spring planting two years after a burn was 10 cm. When compared to the average growth curve for Cariboo, planting on a fresh burn produced a 50% improvement. Planting on older burns produced a 10% improvement.

Careful handling had no effect on growth in either the first or second years. Survival was not influenced by any experimental factor but a heavy frost severely damaged seedlings on one fall-planted site, and rodents clipped a high proportion of seedlings on another. Growth and survival will be monitored for a further three seasons.

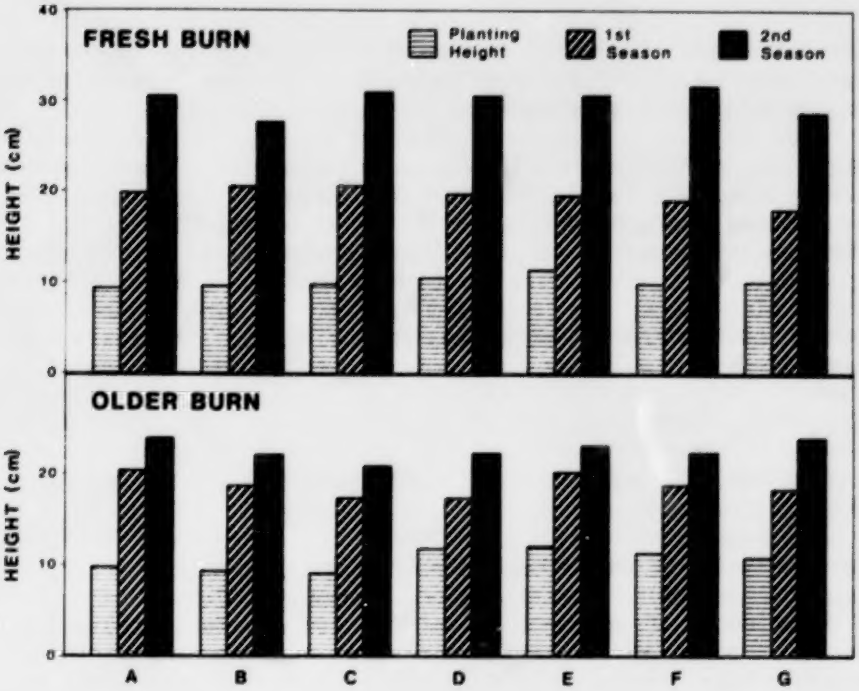

Figure 4. Planting immediately following burning showed a strong effect on height growth for two growing seasons.

DEVELOPMENT OF VEGETATION MANAGEMENT TECHNIQUES FOR COASTAL ALLUVIAL SITES (E.P. 885) J. POLLACK

Investigations in this complex topic area continued. Accomplishments in 1982/83 included the production of working plans for herbicide (E.P. 885.01) and prescribed fire (E.P. 885.03) trials for vegetation management on the rich valley bottom ecosystems in the Coastal Western Hemlock Zone. Also, a revised working plan for large planting stock trials (E.P. 885.04) was produced. These plans, together with the experience gleaned from five related pilot projects established over the past two years, will form the basis of an eight-year vegetation management research program in the coastal portions of the Prince Rupert Forest Region.

CHEMICAL CONTROL OF ROOT MORPHOGENESIS IN CONTAINER SEEDLINGS (E.P. 791) A.N. BURDETT AND C.F. THOMPSON

Mechanical instability in planted lodgepole pine is due to nursery and planting effects on root form. To minimize these effects a chemical root-pruning technique was developed for producing container-grown seedlings with a box-pruned root system (Research Review 1979/80, pp. 25-26). Field trials showed this root-pruning treatment to be effective in promoting the development of an array of primary laterals comparable to that of a naturally-established tree (Research Review 1980/81, p. 16).

Tree pulling tests in the fifth year after planting confirmed that the root-pruning treatment improved mechanical stability of planted lodgepole pine. Height measurements during the first five years indicated that the treatment also increased growth rate. During the first two seasons after planting, growth of stock with a box-pruned root was similar to that of conventional plug stock. In the third to fifth growing seasons, however, height growth of the treated stock was approximately 15% greater than in control seedlings. Statistical analysis showed the difference to be highly significant.

INVESTIGATION INTO THE NUTRITION OF PLANTED WHITE SPRUCE (E.P. 889.02)

T.M. BALLARD

Foliar analysis of planted white spruce in 37 sampling strata in the Cariboo and Prince George Forest Regions commonly indicated slight to severe nitrogen deficiency. Possible (but not necessarily definite) mild deficiencies of boron and magnesium occurred less frequently. Boron and sulfur might become growth-limiting in many cases, if nitrogen deficiency were relieved. Possible iron deficiency occurred frequently. Foliar copper (Cu) concentration in many plantations was low enough that re-analysis by a more sensitive method will be needed to determine whether Cu is deficient. Extreme variability of foliar Cu occurs occasionally, possibly because of local contamination from metal discarded during or after harvesting. This can lead to over-estimates of average Cu concentration if composite samples are analysed. For the more critical nutrients, sampling of 15 seedlings per stratum is adequate to characterize nutrient status.

Scalping of Ah horizons or organic layers during harvesting or site preparation usually results in more severe N deficiency. In an area planted in 1979, 1+0 plug stock had much higher foliar N than 2+1 stock of a different seedlot. The difference was found consistently where the two stock types had been planted in three different surface materials.

PLANTING SITE AND STOCK TREATMENTS FOR BRUSHFIELD CONVERSION (E.P. 933)

L. HERRING

A study was initiated in 1980 to determine the effects of site treatment, stock type, and early fertilization on the growth of white spruce planted on a brushy site in the Sub-Boreal Spruce Zone. Three chemical site preparation treatments were applied to a backlog site in the Walker Creek Valley, 120 km east of Prince George, during July and August 1980. Glyphosate (Roundup) and fosamine (Krenite) were both applied in an aerial spray to manufacturers' recommended rates. Replicated, one hectare plots of these site treatments, together with untreated controls were subsequently planted with nine varieties of white spruce planting stock in the spring 1981. Each planting stock subplot was further split to accommodate two fertilizer treatments. A 40 g application of a 17-7-12 slow release fertilizer was applied to half of each stock type immediately following planting; the remaining half received no fertilizer.

During the first two growing seasons after planting there was substantial reduction in shrub and herb vegetation cover on plots site prepared with glyphosate, compared with that of the controls. Only a minimal reduction in vegetation was observed on fosamine treated plots. Reflecting the degree of vegetation control achieved, seedling survival after two growing seasons for all stock types was 94% on plots treated wih glyphosate, an increase of 16% over control plots (78%). Fosamine site treatment resulted in only a modest 8% improvement over controls. The trend in survival anticipated over the next several growing seasons is for a substantial reduction on fosamine-treated and control plots where overall seedling vigour is poor. Current good vigour and survival is expected to remain constant on glyphosate-treated plots.

Both chemical site treatments resulted in higher seedling height growth increments. The average two-year height growth for all stock types was increased by 42% and 15%, respectively, for glyphosate- and fosamine-treated plots. Fertilization at planting resulted in a combined 63% increase in two-year height growth for seedlings growing on glyphosate-treated plots, compared with unfertilized seedlings on control plots. Fertilization without previous chemical site preparation resulted in no improvement in seedling growth.

PSB 615 and 415 container stocks outperformed all others in two-year height growth performance. Of lower, but similar, growth performance were 2+2, 2+1 and 1 1/2+1 1/2 bareroot stocks, and PSB 313 and 211 container stocks. The poorest performers overall were 2+0 and 3+0 bareroot stocks.

A progress report is in preparation describing these and other results. Successive annual reassessments are planned over the next three years.

POST-PLANTING SPRUCE ECOPHYSIOLOGY (E.P. 966) D. DRAPER, W. BINDER, D. LOUSIER, D. SPITTLEHOUSE, R. MCMINN (CFS)

At present, the physiological component of stock trial research in B.C. is largely confined to the nursery phase of stock development. Physiological data on post-planting seedling performance is required for feedback into the stock production phase. Empirical stock-type trial findings risk becoming inadequate or inconsistent interpretations of stock shortcomings. Post-planting ecophysiology research is complimentary to both existing nursery trial work and to the development of improved measures of plant performance potential. In effect, a more fundamental approach to tackling the regeneration problems in the province is needed - one that expands the technological basis for growing trees. The priority is to address the major concerns about spruce plantation growth in the SBS and ESSF zones in the central and northern interior.

An interdisciplinary team of Research Branch scientists was established to develop a working plan for preliminary studies in 1983/84, in consultation with Dr. R.G. McMinn of the Pacific Forest Research Centre (CFS). This initial work will be associated with operational trials of the Bräcke-mounder cultivator scheduled for the central and northern interior during the summer of 1983.

FALL PLANTING IN THE VANCOUVER FOREST REGION: FIRST APPROXIMATION GUIDELINES AND REVIEW OF AVAILABLE INFORMATION G.K. KRUMLIK

Fall planting in the Vancouver Forest Region has been practiced for almost two decades. Results have been inconsistent, with survival and initial growth being both less than or superior to that achieved in spring planting. However, as the level of planting expands, the question of extending operations into the fall season assumes greater importance. At the request of the Vancouver Forest Region, work was initiated to prepare preliminary guidelines for fall planting. Technical and scientific literature is being reviewed, as well as the knowledge and experience of practicing foresters in the Region. A final report will be prepared by May 1983.

PRELIMINARY GUIDELINES: OPERATIONAL PLANTING OF NOBLE FIR IN THE VANCOUVER FOREST REGION F.T. PENDL AND B.N. D'ANJOU

Noble fir has shown the potential to outperform several other species in terms of early height growth in CFS/MOF plantings on Vancouver Island (E.P. 759). Within and north of its natural range in Washington, noble fir is now replacing Douglas-fir in reforestation programs at elevations where planted Douglas-fir has given poor results. With a potential increase in logging at higher elevations in the future, it becomes increasingly important to have another productive species available for reforestation programs.

At the request of the Vancouver Forest Region, information is being compiled in order to develop preliminary guidelines for operational planting of noble fir. The final report, expected in May 1983, will contain:

1. a brief description of the silvics of noble fir, including its natural range, associated climate, natural damaging agents and wood quality;

2. a review of the findings of experimental trials with this species in the Vancouver Forest Region and Pacific Northwest; and
3. preliminary guidelines for planting on an operational basis.

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ACTIVE EXPERIMENTAL PROJECTS

E.P. 500	*Pawlownia* planting trial	C.L. Leadem
E.P. 502	Planting trials in the Prince Rupert Forest Region	J. Pollack
E.P. 589	Survival and initial growth of morphologically defined classes of Douglas-fir planting stock on high site lands subject to dense cover	F.T. Pendl
E.P. 590	Compatibility of tree and grass seeding in the Kamloops Forest Region	M.B. Clark
E.P. 618	Cone crop periodicity in spruce, Nelson Forest Region	C.F. Thompson
E.P. 695	Effect of planting season and stock type on lodgepole pine seedling performance	J. Pollack
E.P. 712	Tree species trial in the Kitimat Valley	J. Pollack

E.P. 741	Biological effectiveness of equipment tested in silvicultural mechanical site preparation trials	R. McMinn (CFS) L.J. Herring
E.P. 759	High elevation species and stock type trials	J.T. Arnott (CFS) F.T. Pendl
E.P. 766	Planting hazard index studies	F.T. Pendl
E.P. 781	Development of reforestation methods for avalanche control	C.F. Thompson
E.P. 790	Plantation trials in the Kamloops Forest Region	M.B. Clark
E.P. 800	Evaluation of drag scarification treatments in the Prince George Forest Region	L.J. Herring
E.P. 802	Plantation performance assessment in the Nelson Forest Region	C.F. Thompson
E.P. 804	Identification of factors influencing the natural regeneration of lodgepole pine	J. Pollack
E.P. 814	Tree species trial on the Queen Charlotte Islands	J. Pollack
E.P. 820	Lodgepole pine distribution with relation to logging by feller-buncher/grapple-skidder logging	M.B. Clark
E.P. 829	Exploratory study of logging and ATV damage in dry belt Douglas-fir	M.B. Clark
E.P. 841	Development of silvicultural prescriptions for drybelt Douglas-fir sites in the Cariboo Forest Region	A. Vyse
E.P. 858	New methods for the production of forest planting stock	A.N. Burdett
E.P. 859	Early growth and survival of interior spruce stock types	R. van den Driessche A. Vyse
E.P. 885	Development of vegetation management techniques for Coastal alluvial sites	J. Pollack

E.P. 889	Development and application of techniques for the diagnosis of forest stand nutrient status	T.M. Ballard
E.P. 893	Ecophysiological studies of regeneration problems in the interior of B.C.	J. Bassman
E.P. 904	Tree species in the Cariboo Forest Region	A. Vyse
E.P. 933	Planting site and stock treatments for brushfield conversion	L. Herring
E.P. 938	Plantation growth performance analysis in the northern interior	D.A. Draper S. Walsh
E.P. 945	Determination of the quantity of mineral soil exposure for satisfactory establishment of domestic grasses on clearcuts	M.B. Clark
E.P. 966	Post-planting spruce ecophysiology	D. Draper D. Spittlehouse D. Lousier W. Binder R. McMinn (CFS)

FOREST PROTECTION

Research in this section is directed at developing methods to reduce damage to commercial forests caused by insects, disease, weed competition and animals. In 1982/83, hare and squirrel population monitoring and damage assessment continued in the Prince George and Cariboo Forest Regions. A final report describing the effects of snowshoe hare feeding damage on lodgepole pine during the first three years after spacing has been completed, and is presently under review. E.P. 839 - Lodgepole pine seed damage by deer mice and related small mammals - will be concluded in 1983/84 with a publication recommending use of alternative foods (e.g. sunflower seed) in direct seeding operations. E.P. 921 - Damage to commercial forests by wildlife in the Vancouver Forest Region - was concluded in 1982, with the preparation of a 1982 Status Report on the problem (Wildlife Habitat Research Report) by D. Howard, summarizing the TAESCO contract report. In collaboration with Protection Branch, a final report is under preparation for E.P. 852 - Test to determine the most lethal trap-tree technique for spruce beetle control.

A considerable amount of progress was made during the year on the issue of forest vegetation management, despite continuing difficulties in hiring a qualified research specialist in this discipline. A problem analysis on forest vegetation management research needs, education, and training in B.C. was prepared on contract, and is presently under review. Concurrently, draft working plans for vegetation management screening trials were prepared within the framework of the CRAFTS 'B' level trial protocol. When approved, these plans will be adopted as a provincial standard, supported by an appropriate Ministry policy statement.

FOREST VEGETATION MANAGEMENT IN B.C. - A PROBLEM ANALYSIS S.G. CONARD

The objectives of this problem analysis are: (1) to describe the principles of and ecological basis for forest vegetation management; (2) to outline potential forest vegetation management problems in B.C.; (3) to discuss forest vegetation management research needs; (4) to make recommendations on personnel requirements to meet those needs; and (5) to discuss the educational resources available in B.C. and make recommendations for their enhancement.

Terms of reference for the problem analysis were limited to land where commercial production of softwood timber is a major management objective.

The problem analysis was conducted through: (1) discussions with Ministry and industrial foresters, researchers, faculty of academic institutions, and pest managers, including appropriate personnel in Research, Silviculture and Protection Branches; (2) visits to field sites; and (3) synthesis of appropriate literature.

Following internal review, the report is expected to be available for general distribution.

THE EFFECTS OF HARE AND SQUIRREL DAMAGE ON MANAGED STANDS IN THE B.C. INTERIOR (E.P. 845) T.P. SULLIVAN

A final report discussing the effects of snowshoe hare feeding damage on lodgepole pine during the first three years after spacing has been completed. An 18-year-old stand (9 ha area with 2.7 ha buffer zone) was manually spaced (2.5 m x 2.5 m) in 1979 at Bowes Creek on the Grove Burn, 20 km east of Prince George. Hare damage and populations were monitored in the spaced and a nearby control stand. The study period corresponded with the late increase, peak, and early decline phases of the 10-year hare population cycle. Negligible damage to crop trees was recorded in the first winter after spacing as hares fed on the fallen pine foliage from the thinning operation. Feeding attacks to spaced trees increased dramatically (74.8% trees damaged) in the subsequent winter before declining to 18.5% in 1981/82. Damage to control crop trees varied from 35-70% during this period.

The total percentage of girdled and semi-girdled stems was 18.1% in the spaced and 29.2% in the control stand. Hare semi-girdling (sub-lethal) damage clearly suppressed diameter growth of crop trees in both stands. Amount of bark and vascular tissue removed did not affect diameter growth during the first three years after thinning. The spatial distribution of girdling and semi-girdling injuries was clumped over the area of both stands. In general, the frequency of attack and amounts of girdling and surface area of damage increased significantly with smaller tree diameter. Trees larger than 60-80 mm diameter appeared to be immune to feeding damage by snowshoe hares. Stands with less than 15 000 stems/ha may be thinned with little compensation for future crop tree loss to hares. Several silvicultural recommendations are suggested to alleviate hare damage to thinned lodgepole pine.

Population levels of red squirrels and consequent damage to thinned trees declined in 1982 in both the Cariboo and Prince George Forest Regions. This follows a consistent level of damage between 1979 and 1981. Therefore, either populations of squirrels reach a critical level when damage is unavoidable or the nutritional physiology (with respect to squirrels) in lodgepole pine varies from one year to another.

PUBLICATIONS

Sullivan, T.P. and D.S. Sullivan. 1982. Barking damage by snowshoe hares and red squirrels in lodgepole pine stands in central British Columbia. Can. J. For. Res. 12:443-448.

Sullivan, T.P. and D.S. Sullivan. 1982. Influence of fertilization on feeding attacks to lodgepole pine by snowshoe hares and red squirrels. For. Chron. 58:264-266.

Sullivan, T.P. and D.S. Sullivan. 1982. Reducing conifer seed predation by use of alternative foods. J. For. 80:499-500.

Sullivan. T.P. and D.S. Sullivan. 1982. The use of alternative foods to reduce lodgepole pine seed predation by small mammals. J. Appl. Ecol. 19:33-45.

Sullivan, T.P. and D.S. Sullivan. [1983]. The use of index lines and damage assessments to estimate population densities of snowshoe hares. Can. J. Zool. In press.

ACTIVE EXPERIMENTAL PROJECTS

E.P. 839	Lodgepole pine seed damage by deer mice and related small mammals	T.P. Sullivan

E.P. 845	The effects of hare and squirrel damage on managed stands in the B.C. interior	T.P. Sullivan
E.P. 852	Test of lethal trap techniques for spruce beetle control	J. Pollack
E.P. 894	Potentially damaging insects in intensively managed stands of interior lodgepole pine	A. Vyse
E.P. 895	Potentially damaging diseases in intensively managed stands of interior lodgepole pine	A. Vyse
E.P. 910	The effects and control of lodgepole pine dwarf mistletoe in the Cariboo Forest Region	E. Wilford

GROWTH AND YIELD STUDIES

Existing resource use policies are changing B.C.'s forests from old growth to second growth forests, and forest management is advancing from an extensive to an intensive level. These changes are shifting the emphasis on growth and yield information needs from information on forest cover, to information on land capability; and from determination of standing volumes, to forecasting of yields. Increasing demands on B.C.'s land base are changing the role of forest management from timber harvesting to integrated resource management. This changing role is shifting the emphasis on growth and yield information needs from data for sustained yield calculations, to information for strategic planning leading to resource allocation decisions.

Managed-stand growth and yield research studies are being undertaken in order to provide information for strategic planning, inventory updating, and formulating improved silvicultural prescriptions.

The research strategy being adopted is to:

1. maintain close working relationships with, and provide consultation to principal users of stand growth and yield estimates;
2. consolidate, review, and use available data;
3. prepare interim yield estimates for users' immediate needs;
4. establish new growth and yield plots which address data deficiencies;
5. develop improved yield estimates.

CONSULTATION AND ADVISORY SERVICES ON GROWTH AND YIELD

The high demand for managed stand growth and yield information was actively addressed by all seven principal researchers and two contractors working in this discipline. Ministry and Sec. 88 project proposals and reports were reviewed, as well as papers submitted by journals, and dissertations and reports prepared by university students. Presentations on interim managed stand yield tables and supporting research studies were given at the Silviculture Officers meeting at Campbell River in May 1982, to Silviculture Branch in Jan. 1983, and at several Biometrics Seminars throughout the year in Victoria. Technical advice was given to BCFP regarding single tree models and plot establishment, to Protection Branch on application of pest activity models and to Inventory Branch on stand monitoring and other mensuration-related topics. Training seminars on forest fertilization were given at Parksville, Sechelt, and Chilliwack in the Vancouver Forest Region.

DEVELOPMENT AND MAINTENANCE OF A GROWTH AND YIELD DATA BASE SYSTEM

I.R. CAMERON

Systems for projecting the growth and yield of managed stands in B.C. are derived from the growth relationships observed in remeasured plots of different ages established over the range of environmental conditions, and subjected to various treatments. Tree data from each plot must be entered into the computer system, edited, documented, summarized, and retrieved for use in growth and yield studies. Metric tree measurements are stored according to the format recommended by the Committee on Standards of Measure and Data Sharing (COSMADS), Western Forestry and Conservation Association.

In 1982/83, plot and stand descriptors were added to the master index for all coastal growth and yield E.P.'s. The remaining backlog of field data was loaded on computer files. Phase 1 and Phase 2 edit routines were developed, and data from the following E.P.'s were edited:

E.P.	No. of Plots	No. of Data Records
62	1	6 533
63	1	5 506
64	1	3 423
65	1	1 558
66	1	2 568
204	1	5 312
205	1	4 816
283	1	3 987
364	15	12 136
365	6	9 135
368	49	5 550
388	20	9 138
418	17	22 017
429	54	5 250
469	16	15 083
499	18	2 252
534	12	7 160
554	47	40 976
571	157	34 300
19	419	196 700

OVERVIEW REPORT ON THE OLDER THINNING AND SPACING EXPERIMENTAL PROJECTS ON VANCOUVER ISLAND S.A.Y. OMULE

Aside from the Forest Productivity Installations (E.P. 703), 15 other thinning and spacing experiments were established on Vancouver Island from as early as 1929. Although these experiments have been measured on several occasions, little analysis of the data or publication of the results has been undertaken.

An overview report was prepared (copies of which are on file and in the library), which outlines the present status of these experiments as well as their design and analytic limitations. Recommendations are made for the future status of each Experimental Project (E.P.) including a program for data analysis and communication of results.

It was concluded that, given their inadequacy in design for statistical hypothesis testing on thinning and spacing, all the experiments should remain active mostly for demonstration and monitoring growth trends.

EXPERIMENTAL THINNING AND PRUNING OF PONDEROSA PINE (E.P. 517) M.B. CLARK

Established in 1957, the objectives of this study were to study the effects of various intensities of thinning on individual trees and, specifically, to determine the intensity of thinning necessary to produce and maintain a growth rate of eight annual rings per 2.5 cm of radial growth. Thinning intensities were control (no thinning), and to radii of 3.0, 4.5, 6.0 and 7.5 m around selected crop trees of three diameter classes - small (7.5-12.5 cm), medium (12.5-17.5 cm), and large (17.5 cm plus). In 1982 measurements were made to determine responses over 25 years to the various intensities of thinning.

Preliminary analyses indicate that all thinning radii produced significantly better growth than the control (no thinning), but thinning had no positive effects on average annual growth rate. The average annual growth rate over all plots, thinning intensities, and diameter classes for the 25 years following thinning was only 61% of the annual growth rate prior to thinning. No crop-trees attained the target growth rate for "peeler logs" of eight annual rings per 2.5 cm of radial growth.

A number of crop trees in one plot of the study have been attacked by Mountain Pine beetle (Dendroctonus ponderosae). Minor attacks by this insect have occurred in the area at varying times over the past 25 years.

ESPACEMENT TRIAL OF SITKA SPRUCE - TERRACE (E.P. 570) J. POLLACK

This excellent growth and yield study for Sitka spruce was established in 1961. A randomized complete blocks design used three replications of four planting densities (478, 748, 1329 and 2990 stems/ha). Mortality at the twenty-one year assessment was less than 1% in the spring 1982.

Preliminary analysis of the data shows that most individual tree characteristics decrease in magnitude as plantation density increases. Arithmetic average dbhob decreased from 14.0 cm at 478 stems/ha to 9.5 cm at 2990 stems/ha with corresponding individual tree basal areas of 169 cm^2 and 78 cm^2 respectively. Average crown diameter also decreased from 3.6 metres at 478 stems/ha to 2.4 metres at 2990 stems/ha. Likewise, diameter of the largest branch at breast height decreased from 2.2 cm at the widest espacement to 1.5 cm at the closest espacement.

Similar decreases were noted in the height of the stand. A marked decrease in average tree height was observed with 8.3 metres at 478 stems/ha declining to 7.0 metres at 2990 stems/ha. Corresponding top heights based upon the largest 100 dbhob stems/ha were 10.58 and 9.75 metres respectively. A detailed report is in progress.

ESPACEMENT TRIAL OF PONDEROSA PINE (E.P. 607) M.B. CLARK AND C.F. THOMPSON

This espacement trial was established in the fall 1962 and spring 1963 at three locations; Falkland (Kamloops Forest Region), Rock Creek, and Cherry Creek (Nelson Forest Region). Five stocking levels were established at each location, with trees being planted on a square grid at 4x4 ft, 8x8 ft, 12x12 ft, 16x16 ft, and 20x20 ft. The objective of the study was to determine the effects of initial spacing in plantations of ponderosa pine on diameter, height and volume growth, and on tree form and ground vegetation.

The trees have been measured at five-year intervals, and were last measured in 1982 after their twentieth growing season. These data are currently being analysed by Dr. W.D. Johnstone and a report is pending.

ESPACEMENT TRIAL OF LODGEPOLE PINE - FRASER LAKE (E.P. 671.02) J. POLLACK

This growth and yield project for lodgepole pine involves four planting densities ranging from 747 to 2990 stems/ha and two provenances arranged in a completely randomized design with three replications. The 1981/82 Forest Research Review summarized the five- and ten-year assessments of the installation. In the fall of 1982 the fifteen-year assessment was completed and preliminary analyses were produced.

Results indicate that relatively small individual tree differences have become progressively larger since the last assessment. Average tree height ranges from 5.8 metres at 747 stems/ha to 5.5 metres at 2990 stems/ha. Arithmetic average dbhob decreases from 8.8 cm at the widest espacement to 6.7 cm at the closest espacement. Crown closure in the 2990 stems/ha planting density has allowed the crown to lift to 85% live crown as compared with 90 to 94% live crown in the more open espacements. Average crown diameter shows a similar trend, with crown diameters of 1.8 metres in the closest espacement, and a progressive increase to 2.6 metres in the widest espacement.

Although substantial numbers of sample trees are infected with western gall rust and stalactiform blister rust, E.P. 671.02 remains a valuable installation. A detailed report on the 15-year results is expected in 1983.

RESPONSES OF IMMATURE DOUGLAS-FIR AND WESTERN HEMLOCK TO THINNING AND FERTILIZER APPLICATION (E.P. 703) P.R. BARKER AND G.A. GODFREY

Processing problems associated with a large backlog of data were resolved during 1982/83 and analysis of six-year growth response information is underway. Results are expected to be published in early 1984, and related workshops are planned for field practitioners and the scientific community. During the fall 1982, a third (nine year) remeasurement was conducted in 24 installations (280 plots). Increment cores were collected from appropriate sample trees, to determine annual changes in growth and proportion of early wood/late wood.

INTERIM MANAGED STAND YIELD ESTIMATES FOR TSA PLANNING F. BARBER

Research Branch is responsible for providing interim managed stand yield estimates for Timber Supply Area (TSA) analyses. These initial estimates are based largely on response information in the scientific literature and will be used until more formal Managed Stand Yield Tables are developed.

Volume-age (VAC's) and Diameter-age curves (DAC's) depicting three silvicultural regimes were prepared for the "Fraser TSA Yield Case Study", October 1982. Similar yield estimates were prepared for lodgepole pine stands in the Cranbrook TSA.

VAC's and DAC's were also prepared for managed stands of white spruce. Annotated bibliographies were compiled for intensive silvicultural treatments of spruce, western hemlock, lodgepole and ponderosa pine stands. A report entitled "Ponderosa Pine Responses to Thinning: Literature Survey and Recommendations" was compiled for the Cranbrook TSA.

RESPONSES OF THINNED IMMATURE LODGEPOLE PINE TO FERTILIZER APPLICATION (E.P. 886.01) P.R. BARKER AND R.P. BROCKLEY

Five new installations were established during 1982. Two experiments in the Nelson Forest Region are located in stands 18 years old. One area had previously been spaced to 1100 stems/ha, and all plots on the other site were thinned to a comparable density immediately after fertilizing. A similar pair of trials began in the Prince Rupert Forest Region, using 25-year-old lodgepole pine spaced to 1600 stems/ha. The fifth study is situated near Prince George, and involves 18-year-old trees thinned to 1100 stems/ha. All areas contain nine plots, to accomodate three replications of each fertilizing treatment. Besides establishing these installations, extensive reconnaissance was undertaken, to identify stands for further work during 1983.

Under the direction of Dr. T.M. Ballard (UBC), duplicate analysis of 63 composite samples of lodgepole pine foliage was carried out for N, P, K, Ca, Mg, S, Mn, Zn, Cu, B, total Fe, and "active" Fe. Total Fe and Cu recovered by the Parkinson and Allen digestion method were low, and must be re-analysed by other methods. Data were evaluated by the diagnostic computer program DIAGPICO. Results show many of the deficiencies commonly noted in interior lodgepole pine: severe N deficiency, slight P deficiency, and possible Fe deficiency are common. Some samples were quite unusual, having about the lowest foliar B levels yet found in pine in B.C. With foliar B concentrations between 1.5 and 5 ppm, these trees are almost certainly quite boron deficient.

RESPONSE OF LOW MERCHANTABILITY, REPRESSED LODGEPOLE PINE TO SPACING AND FERTILIZATION (E.P. 886.03) D.A. DRAPER

A second installation was established at Baboon Lake (PRFR) in co-operation with regional silviculture and district staff. The selected stand was 45 years of age, approximately 6100 stems/ha on a mid-slope SBS_e 01 site. Crop-tree crown length was 35-40%. The stand was fertilized with 150 kg N as urea in mid-September 1982. The stand was operationally spaced to 1322 stems/ha (2.75x2.75 m) in late September 1982. An establishment report was completed and is on file.

THE EFFECT OF SPACING ON THE GROWTH AND YIELD OF LODGEPOLE PINE (E.P. 922) W.D. JOHNSTONE AND R.P. BROCKLEY

At present, there is insufficient information on the effects of site, age, and stand density on the growth and yield of lodgepole pine to support the development of managed-stand yield tables for this species. The purpose of this study is to remedy the situation by initiating a comprehensive study to secure the required data base.

A working plan was developed and pilot-scale implementation of the plan was carried out. However, due to budgetary constraints only one installation was established, at the Bobtail Forest Road (PGFR), and plans for the southern installation were postponed.

During 1982/83, three reports were prepared and published based upon data from lodgepole pine thinning trials conducted in Alberta, and study findings were reported at various meetings and workshops.

DEVELOPMENT AND APPLICATION OF THE LODGEPOLE PINE GROWTH MODEL, TASS-Pl

(E.P. 850) J.W. GOUDIE AND K.J. MITCHELL

The construction of first approximation managed-stand yield tables for spaced stands was completed, and regional data on stocking levels and treatment costs assembled. The economic module of TASS has been installed and tested, and stocking guidelines are under preparation.

DEVELOPMENT AND APPLICATION OF THE DOUGLAS-FIR GROWTH MODEL, TASS-Df

(E.P. 927) K.J. MITCHELL AND J.W. GOUDIE

First approximation managed-stand yield tables were completed for coastal Douglas-fir plantations, covering a range of espacement and juvenile spacing treatment options. The development of a fertilizer subroutine for TASS-Df is continuing. Construction of managed-stand yield tables for commercial thinning was postponed because permanent sample plot data will not be processed until late 1983, and because of the urgent need to evaluate site index curves applicable to B.C. A study initiated for the February 1982 Slashburning Ecology Workshop in Parksville was completed, and a report prepared entitled 'Impact of stocking level and spatial distribution on forest yield'.

International co-operation with the government of France led to the preparation of Douglas-fir yield tables for France, a tour of plantations throughout the country, and presentation of the results of the cooperative study at a IUFRO conference in Vienna.

EVALUATION AND DEVELOPMENT OF SITE INDEX EQUATIONS FOR MANAGED STANDS

K.J. MITCHELL

A graphics system was developed which will convert existing site curves and equations to a common base, and display them on a common scale for visual comparison. A comparison was initiated of permanent sample plot data with site curves developed by the Ministry (Hegyi et al. 1979) and the U.S. Forest Service (Bruce 1981).

PUBLICATIONS

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Mitchell, K.J., H. Oswald and J.M. Ottorini. 1983. Modelling the growth of Douglas-fir in France. In Forest Growth Modelling and Simulation. Mitt. der forstl. Bundesversuchsanstalt Wien. Heft Nr. 147, pp. 25-39.

ACTIVE EXPERIMENTAL PROJECTS

E.P. 62, 63 64, 66 283	Successive thinnings in a natural stand of Douglas-fir	S.A.Y. Omule
E.P. 204, 205 499	Thinning and pruning demonstration plots	S.A.Y. Omule
E.P. 364	Commercial thinning study in Coastal Douglas-fir	S.A.Y. Omule
E.P. 365	Thinning study in Coastal Douglas-fir	S.A.Y. Omule
E.P. 368	Adaptability of tree species to sites	S.A.Y. Omule
E.P. 370	Partial cutting in the Columbia Forest Zone	C.F. Thompson
E.P. 384, 385	Thinning experiments in lodgepole pine, Canal Flats	C.F. Thompson
E.P. 388	Commercial thinnings in western hemlock, East Thurlow Island	S.A.Y. Omule

E.P. 418, 469 554	Correlated curve trend studies in Coastal Douglas-fir	S.A.Y. Omule
E.P. 429	Spacing trials of pure and mixed stands	S.A.Y. Omule
E.P. 511	Crop-tree thinning of western larch Perry Creek, East Kootenay	C.F. Thompson
E.P. 517	Experimental thinning and pruning of Ponderosa pine	M.B. Clark
E.P. 534	Spacing trial of Douglas-fir, 16 Creek Vancouver Island	S.A.Y. Omule
E.P. 549	White spruce espacement trial, Anzac and Buckhorn Lake	L.J. Herring
E.P. 570	Espacement trial of Sitka spruce, Terrace	J. Pollack
E.P. 571	Tree species and espacement trial, west coast Vancouver Island	S.A.Y. Omule
E.P. 607	Effects of initial spacing of the growth and development of Ponderosa pine	M.B. Clark C.F. Thompson
E.P. 630	Effects of juvenile spacing on individual tree growth in overstocked stands of lodgepole pine, Sheraton	J. Pollack
E.P. 660	Trial of tree species and espacement in the Sub-Boreal Spruce Biogeoclimatic Zone	L.J. Herring
E.P. 671	Spacing trials in lodgepole pine	M.B. Clark J. Pollack L. J. Herring
E.P. 703	Responses of immature Douglas-fir and western hemlock to thinning and fertilizer application	P.R. Barker, G.A. Godfrey
E.P. 789	Growth enhancement options for dense immature lodgepole pine stands	L.J. Herring
E.P. 842	The effects of stand density on the top height of lodgepole pine stands in the Cariboo Forest Region	A. Vyse

E.P. 850	Development and application of the lodgepole pine growth model (TASS-Pl)	J.W. Goudie K.J. Mitchell
E.P. 867	Tree Injector System	B. Dillistone
E.P. 870	Fate of nitrogenous fertilizers applied to snow	V. Marshall (CFS)
E.P. 886	Fertilizing and thinning in interior forests	P.R. Barker R.P. Brockley D.A. Draper
E.P. 922	The effect of spacing on the growth and yield of lodgepole pine	W. Johnstone
E.P. 927	Development and application of the Douglas-fir growth model	K.J. Mitchell J.W. Goudie
E.P. 928	Quality control in the production of nursery planting stock	A.N. Burdett
E.P. 932	An investigation of topophysis in the repression of lodgepole pine	D.A. Draper
E.P. 962	A comprehensive study to determine the effects of initial espacement and subsequent thinning on the growth and yield of lodgepole pine plantations	W.D. Johnstone
E.P. 964	Espacement trials in the Prince Rupert Forest Region	D. Coates

TREE IMPROVEMENT AND RESEARCH STATIONS

K. Illingworth, Manager

Staff changes in the Tree Improvement Section during 1982/83 reflect increased demands on the section from the rapidly developing co-operative programs of the Coast and Interior Tree Improvement Councils, and from the pressing need to maintain, assess and evaluate a fast-growing estate of maturing provenance and progeny test plantations.

The inception of a program for the genetic improvement of Douglas-fir in the interior was advanced to 1982 to permit advantage being taken of a good cone crop in the central interior. To prepare a breeding strategy at rather short notice, and to drive the program, necessitated the transfer of Barry Jaquish from his previous duties in interior spruce progeny testing (E.P. 819) - a large and new project which is now being implemented by Gyula Kiss.

In February 1983, Michael Carlson, having completed his doctoral program at the University of California, joined the section as forest geneticist at Kalamalka Research Station (KRS) where he will study and breed lodgepole pine (E.P. 770). His arrival permits the full-time assignment of Dr. Cheng Ying to the direction of a very comprehensive program of provenance research and, in particular, to commitments leading to the early revision of seed transfer rules and, where appropriate, redefinition of breeding zones for the major conifers.

Propagation, rootstock- and progeny-rearing, and clone-banking have become major functions at the research stations, in response to the growing needs of the co-operative tree improvement and seed orchard programs. Concurrently, the educational and public information role of the stations has also increased, particularly at Cowichan Lake Research Station (CLRS) where, to meet these needs, re-organization entailed the appointment of D. Carson as Nursery and Camp Superintendent, replaced by J. Ogg as Propagation Technician, and by the appointment of J. Woods as Gene Archive Officer, to plan, develop and manage archives of genetic material for purposes of breeding, research and gene conservation.

SERVICES

The service function of the section with respect to the operation of research stations and facilities at Cowichan, Red Rock and Kalamalka has been described (Forest Research Review 1981/82, pp. 60-61).

Developments in 1982/83 include the clearing and cultivation at Red Rock of 25 ha for clone banks and 64 ha for Douglas-fir and spruce progeny tests.

At CLRS a plan to guide clone bank development and management was approved, and site preparation continued on another 15 ha, raising the total area available for master clone banks and gene archives to 60 ha. New plantings include 2 208 western hemlock and 1 096 Douglas-fir ramets.

Although some grafting was done at all stations, CLRS had by far the largest program with spring 1983 propagation totalling 25 000 grafts of eight species, plus 20 000 rooted cuttings of yellow cypress (12 M), western hemlock and redcedar (8 M). A total of 85 000 grafts is being maintained in holding areas pending development of clone banks, breeding arboreta and seed orchards.

The role of all research stations for meetings, training, public information and technology transfer is important and increased during 1982/83, accounting for a not inconsiderable demand on staff time. At CLRS, for example, 48 guided parties of 20 or more persons were accommodated, 33 of which stayed at the camp (Table 5).

A particularly successful two-day workshop on disease, insect, and cultural treatment of propagation stock was attended by technical staff of cooperating agencies in the seed orchard and tree improvement programs.

Table 5. Guided tours at Cowichan Lake Research Station in the fiscal year 1982-83

TYPE OF GROUP	NUMBER OF TOURS
School classes (Elementary and Secondary)	10
College and University Students (Canadian)	7
College and University Students (Foreign)	4
Professional Groups (Canada, USA, Scotland, Sweden, France, China)	10
Groups attending training courses at the Station	5
Information tours for Forest Service Personnel	8
Public Open House	4
Total	48
NUMBER OF GROUPS STAYING IN CAMP	
Ministry of Forests	17
Others	16
Total	33

VARIATION STUDIES

Scheduled maintenance and assessments were continued in studies of genetic variation associated with the biogeography of 10 northwest conifers, and of the interaction between population samples (provenances) and a wide array of test environments.

In a comparative study of coast Douglas-fir seed sources (E.P. 599), height and diameter after 10 years in the field were recorded at five test locations. This brings the total number of sites with 10-year data to 32. Correlation coefficients between 6th- and 10th-year total height varied among sites from 0.75 to 0.97, being less than 0.8 at only two sites. These statistics indicate no significant change in ranking among provenances for height growth, providing continued support for conclusions based on sixth-year data (Illingworth 1978). In consequence, coast Douglas-fir breeding zones and seed transfer rules are currently being re-examined, and the Douglas-fir breeding population is being "enriched" by the introduction of fastgrowing, adapted clones and seed from western Washington (E.P. 708). Fifteen-year data will be forthcoming from five of these provenance trials in 1983.

The evaluation of 15-year results from interior spruce provenance and progeny tests (Jaquish et al. 1982) enabled a recent, interim revision of seed transfer rules and seed orchard planning zones for these species, and identified areas to guide future selection of parent ("plus") trees and cone collection.

PROPAGATION AND EVALUATION OF LODGEPOLE PINE BREEDING MATERIAL (E.P. 699)

C.C. YING

Assessment of Growth

Heights and diameters of approximately 15 000 trees representing nearly 780 wind-pollinated families (E.P. 699.04) in the Red Rock arboretum, near Prince George, were measured in 1982, 10 years after planting and 14 years from seed. Preliminary analyses indicate only minor rank changes in mean heights of populations since the sixth-year assessment in 1978. In particular, eight populations from provenances at low and intermediate elevations (below 1200 m) bordering the interior wet belt remain among the ten most vigorous identified in 1978.

Illingworth, K. 1978. Douglas-fir provenance trials in coastal British Columbia - results to six years after planting. Proc. IUFRO Joint Mtg. of Working Party on Douglas-fir provenances. Vancouver, Canada, Vol. 1:411-425.

Jaquish, B., G. Kiss and C.C. Ying. 1982. An evaluation of interior spruce seed zones and seed transfer rules based on genecological, provenance and progeny test results. B.C. MOF, Unpubl.

Rust and Needlecast Infections

Infections by western gall and stalactiform rusts were recorded in two blocks of the arboretum. Thirty-two percent of the surviving trees were found to be infected, not including those trees, approximately 4%, already killed by or removed because of severe stem infection. A fast-growing population from the interior wet belt (Inonoaklin, #57) was least infected (12%). It was also free of infection by needle cast diseases, primarily Lophodermella concolor. More detailed analyses are being continued to elucidate patterns of variation and levels of putative resistance and susceptibility.

Flowering

Flower production in clonebanks (E.P. 699.02/.03) at Red Rock, increased markedly in 1982, 10 years after establishment. Every living graft produced an average of 240 seed cones and 200 pollen clusters. An estimated 13 kg of seeds could have been harvested. The results clearly indicate that Red Rock is a suitable seed orchard location for lodgepole pine from the northern and central interior of B.C.

The increase in pollen cone production in the Red Rock lodgepole pine arboretum (E.P. 699.04) was also dramatic:

Year	Average number per living tree	
	seed cone	pollen cone
1979	2	5
1980	25	33
1981	24	120

Correlation coefficients of seed and pollen cone production with latitude were respectively -0.5 and -0.89, and -0.67 and -0.80 with longitude. In 1981 provenances from south of Red Rock produced an average of 26 seed cones and 173 pollen clusters versus 21 seed cones and 42 pollen clusters for those from the north. This trend seems to contradict the customary enhancement of flower production by southward transfer, but it may be explained by the generally larger size of trees from southern origins, for correlations between flower production and total height on the basis of provenance means were significant and positive, 0.64 and 0.86 for seed and pollen cones respectively. This result offers support to the earlier finding that trees with superiority in vegetative growth are favoured with cone production, at least in the juvenile stage.

VARIATION IN LODGEPOLE PINE WITH PARTICULAR REFERENCE TO BRITISH COLUMBIA (E.P. 657) C.C. YING

Data interpretation and its practical application continue to be the highest priority. The heights of 153 provenances in the nursery were compared with their height at age six (three years after planting) and age nine. Correlation coefficients (Table 6) were low and most of them were not statistically significant. Correlation between nursery and field growth declined from age six to nine (Table 6). Thus, juvenile performance in the nursery is not a reliable indicator of their eventual growth in the field. In fact, the top 20% of provenances at the nursery, which were either of coastal origin or from the Cascade Mountain Range, turned out to be among the poorest in the field because of winter injury. Nursery results may be used to cull the bottom 10 to 20% of the trees if the nursery is located in an area with a climate similar to that of the planting sites.

Field observations indicate that height growth is a good indicator of the suitability of a provenance on productive sites with a mild climate. However, at sites in harsh environments such as high elevations, snow belts, and areas with high pest hazard, height growth alone is not enough to identify the suitable provenances. For example, at Roddy Creek, near Vernon, the fastest growing provenances, #57 (Inonoaklin) and #72 (Larch Hills), suffered extensive "toppling" as a result of snow press.

Tenth year (age 13) data are scheduled for collection at 60 sites in 1983. Besides total height, assessment of other characteristics such as tree condition and toppling are also planned.

Table 6. Correlation coefficients between nursery and field growth

Region	Correlation of nursery height with	
	Age 6 height	Age 9 height
1 Kootenay	.46*	.52*
2 Monashee	.39*	.25
3 Thompson Plateau	.33	.21
4 Columbia	.36*	.26
5 Cariboo	.52*	.49*
6 Chilcotin	.41*	.29
7 Upper Fraser	.33	.26
8 Willow	.31	.32
9 Nechako	.31	.44*
10 MacKenzie	.15	.15
11 Takla	.10	.11
12 Liard	-.13	-.09

*Significant at P = 0.05

GRAND FIR PROVENANCE STUDY (E.P. 823) C.C. YING

Overall survival in the fall of 1982 (third year after planting) was 95%. Provenance differences in survival varied from 90 to 99% and were not statistically significant.

Provenances varied significantly in total height and leader growth. At most test sites, the tallest provenance grew twice as fast as the shortest one; total height averaged over four sites varied from 55 to 87 cm, and leader growth during the third growing season ranged from 17 to 28 cm.

Generally, provenances from along the east coast of Vancouver Island were fast growing. High elevation and inland provenances grew more slowly. Two low-elevation provenances from the southern Oregon Coast, Norway (#56) and Otter Point (#57), also grew fast, but had more trees with multiple leaders, lammas growth, and frost injury. Terminal leader elongation showed the same geographic pattern as total height growth.

These early results suggest that grand fir is genetically variable in growth and other characteristics, and that selection of productive provenances is feasible. Fast-growing grand fir provenances may be a potential substitute for Sitka spruce on sites prone to severe white pine weevil attack.

NOBLE FIR PROVENANCE STUDY (E.P. 857) C.C. YING

Survival after the first winter was high on sites with a strong oceanic climate (84.5-96.8%), but poor on two sites in the coastal-interior transition zone (24.7% and 50.9%). Preliminary indications suggest that noble fir is a potential reforestation species for high elevation sites in relatively mild climates such as in the Coastal Western Hemlock (CWH) and the Mountain Hemlock (MH) zones.

BREEDING ARBORETA FOR INTERIOR DOUGLAS-FIR AND WESTERN LARCH (E.P. 710, 711)

B.C. JAQUISH

In 1982, in addition to the completion of weeding and other maintenance, preliminary analysis of 1981 survival and height data (six years after planting) was completed. Highlights of these interim results are:

1. Of the top 10 Douglas-fir provenances, six were local and four were from the Coast-Interior (CIT) Zone;
2. A significant inverse relationship existed between provenance elevation and mean height;
3. Dry belt and more northerly provenances performed poorly;
4. Mean plantation survival was good (93%).

WOOD DENSITY ASSESSMENT OF INTERIOR DOUGLAS-FIR PARENT TREES R.M. KELLOGG

The development of an unusually large cone crop over much of the Interior Douglas-fir range prompted the initiation of a parent tree selection program for this species during the summer of 1983. Forintek Canada Corp. assisted in this program by determining the specific gravity of two breast-height increment cores collected by field crews from each tree selected. The specific gravity was determined separately for both the inner and outer halves of each pith to bark increment core. All core samples were examined for the presence of knot material, compression wood, decay, and pitch streaks. Specific gravity values for samples containing such material were excluded from the averages for the tree.

Specific gravity values were reported for a total of 632 trees received from 18 different companies or Ministry of Forests' nurseries. The results demonstrate two things: First, the inner half core specific gravity values are predominantly lower than those of the corresponding outer half, reflecting the influence of the lower specific gravity juvenile wood for this species. Second, a great deal of variation in density was observed between trees, which at least offers promise for improving wood specific gravity through parent tree selection.

Statistical analysis of the data will be completed after the trees have been assigned to particular seed planning areas.

TREE BREEDING AND ASSOCIATED RESEARCH

Tree improvement programs, with associated research in areas such as population genetics, reproductive morphology, propagation, and pollen management, have been established for coastal Douglas-fir, western hemlock, lodgepole pine, interior spruces and, commencing with parental selections in spring 1982, for Interior Douglas-fir. To meet goals recently defined by Coast and Interior Tree Improvement Councils, all programs were reviewed during the past two years and, where appropriate, breeding objectives and strategies for achieving them were re-adjusted. In particular, following cost-benefit evaluations of individual programs, the emphasis in interior programs has been shifted from the immediate establishment of untested clonal seed orchards, to the early establishment of progeny tests and the preservation of cloned parental selections in gene archives, breeding arboreta, and holding areas (for eventual transfer of 50% of the clones to seed orchards, as indicated by early progeny test data).

This method has proved very effective with the interior spruce breeding program (E.P. 670), which is now producing tested clones for the establishment of 1.5-generation orchards to supply some seven seed orchard planning zones with genetically-improved seed.

GENETIC IMPROVEMENT OF INTERIOR SPRUCES IN B.C. (E.P. 670) G.K. KISS

Breeding Arboreta and Clone Banks

Maintenance (i.e. irrigation, weeding, fertilizing, and pest control) of breeding arboreta continued at the Kalamalka Research Station and Seed Orchard (KRS). Moderate production of strobili permitted the collection of 130 lots of pollen in the spring of 1982. Earlier tests indicate that spruce pollen can be stored at -20°C for at least three winters without appreciable loss of viability, provided that moisture content does not exceed 6%. Stored pollen will facilitate future controlled cross experiments (i.e. E.P. 670.71, discussed elsewhere in this report).

A number of controlled crosses were also carried out in 1982. Eleven of these crosses have sufficient seed to be included in E.P. 670.71. Until all crosses are completed for that project, the seed lots are stored at -20°C.

Fertilization and incidental maintenance were carried out at the Red Rock clone bank. As a result of fertilizing, excellent scion material was produced and collected for use in the establishment of 1.5-generation seed orchards.

About 200 ramets were lost to unusually severe drought at the Barnes Creek clone bank, 60 km northeast of Vernon. Losses occurred mostly among grafts planted in 1981 which had not had time to develop adequate root systems. In order to prevent recurrence of similar losses, steps are being taken to install an emergency irrigation system. Routine maintenance of surviving grafts at Barnes Creek continued in 1982/83. They appear to be in good health and future losses are expected to be minimal.

Progeny Trials

Ten-year height measurements were taken of the progeny trials representing the Prince George Selection Unit (174 parents) in the fall of 1982. Statistical analyses of the data are in progress and should be completed in 1983/84.

E.P. 670.70 (Miscellaneous controlled crosses - pilot project), a small new project, was established in 1982. The objectives of the study are to:

1. compare the performance of controlled crosses with open-pollinated progenies;
2. estimate heritability based on one parental component;
3. assist in the design of future full-sib progeny trials;
4. compare reciprocal plantings (north with south); and
5. use the strategically-located plantations for demonstration purposes.

The experiment consists of 25 crosses, using four male parents, and five of the top-ranking open-pollinated (o.p.) progenies from the Prince George selection unit. Four seedlings per replicate, five replicates per site at each of three planting sites, represent each of the 25 crosses and five o.p. progenies. Plantations are located at the Red Rock Forest Reserve (south of Prince George), Barnes Creek (northeast of Vernon), and Perry Creek (northwest of Cranbrook).

Associated Research

A proposal for a comprehensive breeding research program was submitted and accepted in principle in 1982. The study is intended to:

1. estimate the accuracy of open-pollinated progeny trials as a measure of general combining ability (GCA);
2. estimate and compare the magnitude of specific combining ability (SCA) both within and among breeding units (BU's);
3. determine the most profitable mating design in terms of expected gains (by comparing GCA with SCA);
4. obtain more reliable estimates of heritability and genotype x environmental interactions than currently available from o.p. tests;
5. evaluate the adaptability to a range of environments of various combinations of controlled crosses;
6. attempt to identify and evaluate traits that might be of value, directly or indirectly, to the breeding program;
7. identify future research needs.

Four BU's were created, one each from the three selection units (Prince George, Prince Rupert, and East Kootenay), by selecting five trees from the top 25% of the ranked families and five from the next 50%. The fourth BU comprises ten clones selected randomly from among the strobili-bearing clones of eastern North American sources.

The crossing program is divided into two main categories:

1. half diallel crosses within BU's
2. partial diallel crosses among BU's making two crosses with each clone in each of the other three BU's.

Upon completion of the crossing program, test plantations are planned for major geographical areas of the province. Eleven crosses have been completed and large numbers of crosses are planned for 1983.

Improved Seed Orchards

Two hundred and sixteen clones from three selection units have been identified from preliminary analysis of o.p. test data. They are being used to constitute the first genetically-improved seed orchards for the interior of B.C. Initially, the top 50% of clones, as determined by the performance of their o.p. progenies six years after field planting, will be established in these orchards at half the ultimate spacing. In 10-15 years, before "commercial" production commences, the poorer 50% of these clones will be eliminated, leaving the top 25% of the originally-selected population in the seed orchard. Estimated height gains in the orchard progeny thus produced range between 10 and 15%. A total of 4500 scions has already been supplied to Silviculture Branch towards the establishment of these 1.5-generation orchards to meet the needs of seven seed orchard planning zones.

OPEN-POLLINATED PROGENY TESTING FOR INTERIOR SPRUCE SEED ORCHARD ESTABLISHMENT (E.P. 819)

G.K. KISS

Expansion of the original spruce progeny testing program (E.P. 670) became possible with the addition of numerous parent trees selected by the Silviculture Branch, MOF, and co-operating agencies. In order to maintain E.P. 670 on a manageable level, a new E.P. number (E.P. 819) was assigned to this project.

Basically, the project follows the guidelines set out in E.P. 670. Seven northern seed orchard zones (SOZ) were delineated on the basis of biogeoclimatic information as follows:

Bulkley Valley	(BV)
Quesnel Lakes	(QL)
Finlay	(F)
Central Plateau	(CP)
Mount Robson	(MR)
McGregor	(MG)
Hudson's Hope	(HH)

Local o.p. progenies will be tested on two or three test sites in each zone (i.e. parents will be tested only within their zones). Families of each SOZ will be randomly divided into 3-5 equal-sized groups (sets). Sets will be distributed randomly in each of the eight replications within a test site. Individual plots, consisting of four seedlings, will be assigned to rows within the set at random. Figure 5 depicts the experimental design.

Rep 1	Rep 2		Rep 8
Set 1 Set 2 Set 3 Set 4	Set 3 Set 4 Set 1 Set 2		

Rep 1	Rep 2		Rep 8

Figure 5. Schematic representation of the experimental design of E.P. 819.

Statistical analyses will include ANOVAs by site and across sites. The analyses will permit the calculation of both family and individual heritabilities. Models of the ANOVAs are available upon request.

Testing for three zones (BV, QL and F) will commence in 1983. In preparation for sowing, 556 seedlots were stratified and sent to the Red Rock Research Nursery. Field planting is scheduled for spring 1984. Families representing the remaining zones will be tested in subsequent years.

Results from these test will be used to constitute and subsequently to cull seed orchards, as outlined in E.P. 670.

LODGEPOLE PINE TREE IMPROVEMENT (E.P. 770) M. CARLSON

The selection and breeding of interior lodgepole pine was commenced by the Ministry of Forests in 1975, as part of its overall plan for the intensive management of the provincial forest resource. To meet needs identified by the recently formed Interior Tree Improvement Council (ITIC), and through opportunities for co-operation presented by the council, this program is currently being reviewed and revised to ensure an economically and ecologically sound breeding program to complement an overall silvicultural strategy for the species.

The long-term goal of the program is, through selective breeding, to produce lodgepole pine planting stock with an inherent potential for more rapid volume growth, better form, and equivalent or better wood quality characteristics than the current resource. Its main components comprise the design and implementation of selection, progeny testing and breeding schemes. In addition, exploratory research will elucidate questions relating to the development and success of the project in the long term, such as those concerning natural population structure, quantitative variation, adaptation, stability of performance, and reproductive biology.

Base Population Selection

The immediate goal is to develop "adequate" base populations for each of four or five broad geographic areas. With from 500 to 600 parent trees per selection unit, selection programs are being planned based upon provenance test data, regional growth potentials, and biological and socio-economic considerations. In 1982/83, an additional 300 selections were made in the Okanagan area, raising the overall total to almost 1100 trees selected throughout the province. Most of these have been grafted in clone banks and have seed available for parental evaluation in progeny tests. Wood density estimation from sample cores is also progressing well (under Dr. R.M. Kellogg, Forintek Canada Corp.).

Progeny Testing

Wind-pollinated seed from 80 selections in the Okanagan were prepared for sowing in spring 1983, at Kalamalka Research Station and Seed Orchard. The resulting progenies will be planted at five locations in this selection unit in spring 1984. The intent of these and future tests is to make an initial screening of first generation phenotypic selections. The performance of wind pollinated families will provide a measure of general combining ability (or breeding value) and a basis for eliminating approximately 25% of the original selections from the breeding population. The second round of progeny testing will be designed to identify both good general and good specific combiners, as well as to create a base population for second generation selection.

Twenty of the eighty families referred to above are being used in a test to provide early information on the efficiency of contiguous versus non-contiguous plot designs, that is, to assess the "trade-offs" between record-keeping logistics using 3-tree row plots compared to single tree plots. The test will also permit variable spacing comparisons to determine the merits of various test-seedling densities for the early prediction of family rankings and for estimating genetic variances.

WESTERN HEMLOCK TREE IMPROVEMENT (E.P. 813) M. MEAGHER

Following the review of the program's scope and direction in 1981/82 (Research Review 1981/82) and the change to a program of controlled mating without prior screening of parents by open-pollinated progeny tests, considerable work ensued to identify suitable clones for the breeding population. Where possible, data from the Canadian Forestry Service provenance test and Tahsis Co. progeny tests were used, supplemented by consideration of geographic distribution, stem form and wood specific gravity, to nominate about 400 parents from the lower Coastal area (Vancouver Forest Region). The need for some further selections was established, and these have since been obtained with the help of member agencies of the Coast Tree Improvement Council (CTIC). The total number of trees selected for the program now is 1334. Those not in seed orchards or the breeding program will be planted in the master clone bank at Cowichan Lake Research Station for possible future use. Once the current review of long-term planting needs is completed and analysed, selection of more trees from the Prince Rupert Forest Region may be warranted. Selection of approximately 100 clones from coastal Washington is planned once progeny-test data from co-operators are available.

Clonal lists for all seven approved seed orchards were reviewed and final lists were recommended for three orchards. Selection for the remaining orchards is well advanced. All propagation is being done by staff at Cowichan Lake Research Station, with very good results.

The last of a series of parent-ranking ("progeny") tests using open-pollinated seeds was established on seven sites in spring 1982. Seventy-seven parents are included, bringing the number under test to 145 on 23 sites. More first-year mortality occurred than usual, but still the average survival was 90%. Dead trees were replaced in spring 1983. An evaluation of the 33 families on the eight sites in the first series is planned for autumn 1983, when the trees will be five years old. The most pressing maintenance (brush and wildling hemlock removal) was conducted on all sites by seasonal staff. Some similar work was conducted on a Canadian Forestry Service provenance test site.

A 12-parent diallel mating, plus open-pollinated seeds from each tree, was sown at CLRS to provide good estimates of genetic parameters and to guide the operational breeding program. Poor germinaton in some families necessitated a second sowing in June, both to check seed germinability and to provide more seedlings, thereby maintaining necessary balance in the test. While few genetic markers have appeared, striking differences between parents, and between some crosses, are apparent. The test will be planted in autumn 1983.

A small-scale "operational" trial of cone induction on potted ramets was conducted at CLRS (E.P. 865.07) by Station staff. The treated ramets responded well and were mated indoors in March 1983, since all are in the proposed breeding population. Sufficient pollen was collected from five stand trees in 1982 to permit Dr. J. Webber to include them in studies of storage methods and duration.

PROGENY TEST OF COASTAL DOUGLAS-FIR USING A FACTORIAL MATING DESIGN WITH FOUR MALE TESTORS (E.P. 707) J.C. HEAMAN

Tree height and diameter after nine years in the field were measured at the two principal test plantations. Estimates of variance components were calculated and the parents ranked in terms of general combining ability. The figures were summarized for presentation at the Western Forest Genetics Association meeting at Corvallis, Oregon. Both parental ranking and relative values of the variance components had changed little since the last assessment in 1978 or from the published data based on the 1976 assessments (Yeh and Heaman 1982). Non-additive variance was negligible when compared to the additive portion, and no significant genotype by environment interactions appeared over the limited environments of Victoria and Cowichan. Volume comparisons were developed using the formula derived by Kovats (1977). These

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Kovats, M. 1977. Estimating juvenile tree volumes for provenance and progeny testing. Can. J. For Res. 7:335-342.

Yeh, F.C.H. and J.C. Heaman. 1982. Heritabilities, genetic and phenotypic correlations for height and diameter in coastal Douglas-fir. Can. J. For. Res. 12:181-185.

figures were used later in the year by Crown Zellerbach foresters as a basis for selections to be included in a second generation orchard for their private lands.

These plantations are also being used to derive gain estimates in the planning of the overall breeding program, and thus provide a means of examining the options for replacement of the first generation seed orchards.

Raw data and summaries for the same crosses, planted by Dr. R.F. Stettler at the University of Washington Research Forest and by Dr. Kim Ching at Oregon State University, were made available for discussion and to estimate genotype by environmental interaction effects over a wide geographic range.

A plantation of the same crosses, established by MacMillan Bloedel Ltd. at a high elevation in its Shawnigan Division, Vancouver Island, was reviewed and measured. Analysis is not complete but strong micro site differences within and between plots (with accompanying problems of establishment, including severe initial browsing), have reduced the value and precision of the interpretations. The plantation is expected to provide useful information at a later date.

A BREEDING PROGRAM OF COASTAL DOUGLAS-FIR (E.P. 708) J.C. HEAMAN

In 1982, a light crop of reproductive buds in the clone banks permitted resumption of controlled pollinations, and four more disconnected modified-diallel groups were attempted. Some crosses still lack adequate seed numbers and these will be supplemented by repeat crosses in 1983. Twenty-four parents and 60 crosses were involved. As these numbers do not represent an efficient field testing unit, the seed will be held until additional clones can be added in 1983. To assure flowering in 1983, selected ramets of 15 clones in the younger clone bank at C.L.R.S. were root-pruned and treated with $GA_{4/7}$ and some 50 of the older clones were given a girdling treatment to induce flowering. The girdling was successful and nine of the younger clones responded well to the induction treatment.

Maintenance needs of the 77 test plantations were assessed and treatments given on a priority basis. These included removal of brush and wildlings, and application of open-ended milk cartons to protect individual seedlings from browsing during the establishment phase where there is high browsing risk. Some 42 000 cartons must be removed or replaced each year. Where stock was still available from C.L.R.S., dead trees in plantations 45 to 77 were replaced.

An escape fire had damaged plantation 52 (Mt. Prevost), but most of the dead trees were replaced with stock held-over for this purpose. On some sites, herbicide was used to remove grass competition and reduce associated vole problems.

Although no rigid measurement schedule has been established for this project, since differential rates of establishment and the effects of browsing on some sites make overall comparisons at set age-intervals unproductive in the early years, measurements are needed to evaluate progress and to provide information on the variation patterns. Realistic measurements on the first series of 11 plantations appeared feasible, despite reduced resources, through industrial participation, with costs covered by credit to stumpage. Three plantations were assessed and, where necessary, weeded by CTIC members. By the end of the year nine of the eleven had been measured and the data processed. Snow delayed work on the final two sites until spring 1983.

PLUS TREE SELECTION AND REGISTRATION IN COASTAL DOUGLAS-FIR (E.P. 479)
J.C. HEAMAN

This project receives only the minimum input at present and the major accomplishments for the year have been the steps taken in co-operation with U.S. forest companies and agencies to expand the collection of U.S. material for possible use in the future. Through the co-operation of Jim Hargrove, forester for the Quinault Indian Nation, 30 open-pollinated seed collections and scions from the south-west portion of the Olympic Peninsula, Washington, have been provided for the Ministry of Forests breeding collection. Cooperation with Rayonier Inc. at Hoquiam, Washington, will lead to further acquisitions. These collections will not be sown until 1985 for field testing and will eventually provide U.S. clones that will have been tested under B.C. conditions, broadening the options of future tree breeders.

The clones selected for Crown Zellerbach's private orchard are being propagated and registered by the Ministry of Forests and will also be available for future breeding opportunities.

RACIAL CROSSES WITH DOUGLAS-FIR (E.P. 513) J.C. HEAMAN

Unfortunately, project priorities were such that virtually no work was possible on this project in 1982/83. The plantations are well established and mapped, but will require work of measurement, spacing, and evaluation over the next few years.

Some provenances in E.P. 513.98 which were suffering from severe Rhabdocline infestation were removed, and individual seedlings were registered and propagated vegetatively.

GENETIC IMPROVEMENT OF DOUGLAS-FIR IN THE B.C. INTERIOR B.C. JAQUISH

A program for the genetic improvement of interior Douglas-fir, initiated early in 1982 thereby permitting utilization of a good cone crop in the central Interior, advanced very well in its first year. A breeding strategy was proposed, reviewed, and accepted by members of the Interior Tree Improvement Council who subsequently co-operated in the phenotypic selection of some 832 parent trees in four breeding zones. Wind-pollinated seed was collected from 779 of the selections, and progenies from 365 parent trees from the Cariboo Transition (CT) breeding zone are now being grown at CLRS for testing within this zone. To facilitate further breeding zone refinement, seed from 35 selections from adjacent zones was also sown for progeny testing within the CT zone. Planting is scheduled for spring 1984.

Scion material was collected from 136 of the selected parents and grafted at CLRS. In addition, wood cores were sampled from 632 parents for wood density determinations by Dr. R.M. Kellogg, Forintek Canada Corp. (p.).

PROPAGATION AND SEED ORCHARD RESEARCH

Much of the research on reproductive biology, flower enhancement and induction, pollen management and indeed, the broad field of seed orchard technology is carried out by scientists of the tree physiology section, often in collaboration with tree breeders and their technicians, like M. Carlson and S. Ross (E.P. 907). However much useful work has also been carried out independently by tree improvement personnel in association with their programs. Much of the work at CLRS falls into this category, being an integral part of operational activities in clonebanks and propagation programs. In the interests of continuity it is reported under this section.

GRAFTING IN DOUGLAS-FIR (E.P. 648) I. KARLSSON

In 1978 controlled crosses involving a complete diallel were made on six graft-compatible Douglas-fir clones. The objectives of this study were first, to gain information about the influence of rootstock vigor on graft compatibility and growth performance of the grafts; and second, to determine whether the flowering patterns of the rootstocks influence the flowering of the grafts.

Twenty seedlings from each of the 30 crosses were planted on a test site at Skutz Falls near Lake Cowichan in the fall of 1980. The crosses in this plantation will be continuously assessed for growth and flower production. Another 25 seedlings from each of these 30 crosses were potted for rootstocks in the fall of 1980 and grafted in the greenhouse, some in March 1981, and some in March 1982. Five plus tree clones are being used as testers, two of which are heavy cone producers, one intermediate, and two non-producers. These grafts will be field planted in the spring of 1984 on a site at the Research Station. Differences in compatibility, growth rate, and cone production will be studied.

FLOWER STIMULATION IN GENE ARCHIVES AT COWICHAN LAKE RESEARCH STATION (E.P. 780) I. KARLSSON

Stem girdling.

For several years, stem girdling to enhance flowering in Douglas-fir has been tried in the clonebanks at Cowichan Lake Research Station. In the first trials, established in 1973 and 1974, 1/4 inch wide bark strips were removed from two offset half-circumferences of the stem, but any effect on flowering was inconclusive. In May 1975, therefore, the treatment was changed to a complete 1/8 inch wide girdle, and in 1976 a marked increase in flower production was observed. There was also a noticeable carry-over effect to 1977. Although many trees turned chlorotic for a period in the fall following the complete girdling, there appeared to be no appreciable adverse effects. Two of the trees girdled in 1975 were broken by heavy snow loads, and it was felt that, at least temporarily, treated trees may be more susceptible to breakage. Subsequently, during a thinning operation in 1980, two trees were removed which had been girdled in 1975. The stems were cut to permit an internal examination of the girdling wounds, and it was found that complete healing had occurred within two years after the treatment, the rough scar on the surface of the bark being the only visible sign remaining.

In 1976, to stress the trees somewhat less severely, a number of new trees were given an incomplete girdle, a 2.5 cm wide strip of bark being left as a bridge. This did not result in any more cones than on the control.

Complete girdling to increase flowering on trees required for controlled crossing programs was carried out in May 1981 and repeated in May 1982. The trees, especially those treated in 1981, had larger stem diameters than any treated previously. Normally, treatment is applied at such a height on the stem that there are some live branches below the girdle, but on some of these large trees all live branches were above the treated area. The girdles were 1/4 inch wide, that is, wider than in previous complete girdling. All 13 trees treated in 1981 responded with substantial flowering, and over 90% of the 56 trees from the 1982 treatment have reproductive buds for next year. Two of the largest trees girdled in 1981 healed very slowly and have since died. Several of the remaining trees are still weakened from the treatment. It is not yet clear whether the mortality was due to the removal of too-wide a bark strip, or because no live branches were left below the girdle on these large trees. Therefore, in addition to checking flower production, close observations will be made on the recovery and growth of these treated trees.

Supplemental pollination.

Early trials at Cowichan Lake Research Station indicated that booster pollination of Douglas-fir increased cone abortion, particularly during cloudy and wet conditions (Research Review 1979/80, p. 13). Trials using a hand applicator with an inverted bucket caused more abortion than pollen applied with a power duster.

In the spring of 1980, pollen boosting was carried out on 20 heavily flowering trees in a 15-year-old plantation, the objective was to compare applications under both wet and dry weather extremes. Because of insufficient wet days during the pollination period, some trees were treated under conditions of high relative humidity in the early morning. Unfortunately, a heavy infestation of cone insects made meaningful seed counts for the different treatments impossible. However, it was possible to record the cone abortion. Results indicated a direct relationship between relative humidity at the time of boosting and cone abortion. This was even more pronounced when it was raining at the time of application. Generally, it appears that in order to minimize cone abortion, supplemental pollination should only be done during dry and warm conditions and should not start until the relative humidity is below 50%.

To confirm these figures, another study (E.P. 780.08) was started in the spring of 1982. In this test, six grafted plus tree clones were used. The pollen boosting was carried out with an inverted bucket, twice and in some cases three times on each clone, depending on flower development. Although sunny and dry weather dominated during the pollination period, there were sufficient wet days to allow for some clones to be pollen boosted during wet and cloudy weather conditions. Preliminary results confirm the earlier observation that supplemental pollination during wet or humid conditions increases flower abortion. Furthermore, the pollen boosting did not increase the overall seed set compared to the control. There was an increase in the number of filled seeds per cone in one clone, a decrease in two clones and no difference in three clones.

In conclusion, therefore, the value of supplemental pollination under conditions similar to those at CLRS is negative or questionable. The only valid reason for applying extra pollen is the hope that the boosting pollen will swamp out the local pollen, thus improving the genetic quality of the seed.

AMABILIS FIR GRAFTED ON UNDERSTOCK OF FOUR DIFFERENT SPECIES (E.P. 815.02)

I. KARLSSON

Amabilis fir is being grafted at Cowichan Lake Research Station for three clonal orchards of the Coast Tree Improvement Council. Limited propogation experience with this species indicates that it grafts well, but the ramets, which retain their branch-like habit for a considerable period, grow very slowly - possibly reflecting the typically slow initial growth of amabilis fir seedlings.

To explore means of hastening ramet development, a grafting trial using rootstock of faster-growing *Abies* spp. was commenced in March 1981. Thirty amabilis fir grafts were made on rootstock of each of the following species: *A. amabilis*, *A. procera*, *A. grandis* and *A. lasiocarpa*.

Assessment, October 1982

Understock	Survival No.	%	Scion Growth 1982 (cm)
A. amabilis	27	90	9.3
A. grandis	18	60	6.3
A. lasiocarpa	25	83	6.0
A. procera	11	37	4.3

Survival and growth of ramets after two growing seasons demonstrate the superiority of amabilis fir rootstock, provide evidence of incompatibility with rootstock of other species tested, especially *A. procera*, and suggest that heteroplastic grafting is probably not a viable alternative for accelerating ramet development in amabilis fir.

PUBLICATIONS

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El-Kassaby, Y.A., F.C. Yeh and O. Sziklai. 1981. Estimation of the outcrossing rate using allozyme polymorphisms in a natural stand of coastal Douglas-fir (*Pseudotsuga menziesii* var. *menziesii* (Mirb.) Franco). Silvae Genet. 30:182-184.

El-Kassaby, Y.A., F.C. Yeh and O. Sziklai. 1982. Inheritance of allozyme variants in coastal Douglas-fir (*Pseudotsuga menziesii* var. *menziesii* (Mirb.) Franco). Can. J. Genet. Cytol. 24:325-335.

El-Kassaby, Y.A., O. Sziklai and F.C. Yeh. 1982. Linkage relationships among 19 polymorphic allozyme loci in coastal Douglas-fir (*Pseudotsuga menziesii* var. *menziesii* (Mirb.) Franco). Can. J. Genet. Cytol. 24:101-108.

Yeh, F.C.H. and J.C. Heaman. 1982. Heritabilities, genetic and phenotypic correlations for height and diameter in coastal Douglas-fir. Can. J. For. Res. 12:181-185.

ACTIVE EXPERIMENTAL PROJECTS

E.P. 474	Inbreeding and sterility studies with Douglas fir, Cowichan Lake	F.C.H. Yeh
E.P. 479	Plus tree selection and registration of Douglas fir	J.C. Heaman
E.P. 513	Racial crosses with Douglas fir	J.C. Heaman
E.P. 599	Coastal Douglas fir provenance study	C.C. Ying
E.P. 611	Trial of species and provenances: Jennis Bay	C.C. Ying
E.P. 646	Effects of altitudinal and latitudinal displacement of white and Engelmann spruce provenances: Prince George plantations	G.K. Kiss
E.P. 648	Grafting in Douglas fir	I. Karlsson
E.P. 657	Variation in lodgepole pine with particular reference to British Columbia	C.C. Ying
E.P. 662	An altitudinal test of a low elevation seed source of Engelmann spruce, Larch Hills and McGillivray Lake	M.B. Clark
E.P. 670	Genetic improvement of interior spruces in British Columbia	G.K. Kiss
E.P. 672	Effects of altitudinal and latitudinal displacement of white and Engelmann spruce provenances: Prince Rupert plantations	G.K. Kiss

E.P. 688	Douglas fir provenance plantations, Prince George Forest Region	L.J. Herring
E.P. 692	Shore pine spacing and provenance trial	C.C. Ying
E.P. 699	Propagation and evaluation of lodgepole pine breeding material	C.C. Ying
E.P. 702	Geographic variation in Sitka spruce	C.C. Ying
E.P. 705	Spruce Piceta, Chilliwack and Red Rock	G.K. Kiss
E.P. 707	A progeny test of coastal Douglas fir using a factorial mating design with four male testers	J.C. Heaman
E.P. 708	Breeding program of coastal Douglas fir	J.C. Heaman
E.P. 710	Interior Douglas fir breeding arboretum	B. Jaquish
E.P. 711	Western larch breeding arboretum	B. Jaquish
E.P. 750	Yellow cedar plantation at Cowichan Lake Research Station	I. Karlsson
E.P. 770	Genetic improvement of lodgepole pine	M. Carlson
E.P. 771	Photoperiod extension for growth acceleration and flower promotion in lodgepole pine	M. Carlson
E.P. 776	Correlations between quantitative and qualitative attributes	F.C.H. Yeh
E.P. 778	Experimental population genetics in conifers (Electrophoresis)	F.C.H. Yeh
E.P. 779	Root development after planting	I. Karlsson
E.P. 780	Flower stimulation in Douglas fir	I. Karlsson
E.P. 813	Western hemlock tree improvement for coastal British Columbia	M.D. Meagher
E.P. 815	Amabilis fir arboretum	I. Karlsson

E.P. 819	Open-pollinated progeny testing for interior spruce seed orchard establishment	G.K. Kiss
E.P. 823	Grand fir provenance study	C.C. Ying
E.P. 824	Amabilis fir provenance study	C.C. Ying
E.P. 857	Noble fir provenance study	C.C. Ying
E.P. 871	Intensive forestry practices and wood quality	K. Illingworth
E.P. 948	Improving cultural techniques for the propagation of northwest conifers	A.M. Wood

ECOLOGY AND EARTH SCIENCES
T.E. Baker, Manager

With the appointments of J.D. Lousier as Ecology Program Manager and D.V. Meidinger as Provincial Correlator, the Ecology Program gained much-needed support in co-ordination, provincial correlation activities, research planning and design, technical review, and project supervision. Dave Spittlenouse was appointed Research Climatologist for the Branch and has made major contributions to current and proposed studies which contain a climatic component.

The section continued to provide research and operational staff with physical and biological information in a variety of forms. Technology transfer was emphasized and approximately 1000 individuals from government and industry were trained in ecosystem identification and use in forest and range management. A total of 38 internal or published reports were prepared. Staff also spent considerable time providing technical advice to research and operational staff.

ECOLOGY AND ECOSYSTEM CLASSIFICATION
J.D. Lousier, Program Manager

While the major emphasis of the Program remained the Ecosystem Classification Program (E.P. 822), there were more initiatives into ecosystem research, specifically those research areas dealing with ecosystem function, ecological factors, site productivity, and impacts of silvicultural treatments. Each year, as the classification program nears completion and full implementation, greater emphasis will be accorded ecosystem research.

The Grassland Ecology and Classification Symposium held in Kamloops in June 1983 can be considered a significant contribution as it increases our own understanding of this important resource. This was the first time leading scientists were brought together to discuss British Columbia grasslands from a North American perspective. The proceedings provide an important reference on the topic for both operations and research staff.

ECOSYSTEM CLASSIFICATION PROGRAM (E.P. 822) J.D. LOUSIER AND D.V. MEIDINGER

The prime activities within the ecosystem classification program continue to be undertaken in the Regions and involve: field sampling; production of operational manuals, field guides, and biogeoclimatic unit maps; and training.

Headquarters activities included: 1) an evaluation of correlation needs and the development of an "action plan"; 2) documentation of a data processing system for ecological data; 3) continued work on grassland classification and correlation (see E.P. 931); 4) completion of subalpine meadow/alpine classification review; 5) initiation of a problem analysis into the classification of successional ecosystems; and 6) the publication of a taxonomic reference list.

Other notable provincial activities included: 1) the completion of the Forest Ecology chapter of the new U.B.C. Forestry Handbook; 2) continued work on the ecosystem mapping manual; 3) a new system for initiating and processing ecological reserves within the forestry community; and 4) considerable progress in the documentation of our classification system (with regard to concepts, terms, definitions, differentiating criteria, system of nomenclature, and methods of data analysis and synthesis). The first approximation of the new provincial biogeoclimatic zone map has undergone the final revision.

ECOSYSTEM CLASSIFICAION IN THE VANCOUVER FOREST REGION (E.P. 822.01)

F.C. NUSZDORFER, K. KLINKA AND R. GREEN

Mapping of biogeoclimatic units at a scale of 1:500 000 was completed for the southern portion of the Vancouver Forest Region. Preliminary maps were prepared for the northern portion of the region after completion of extensive aerial surveys. In addition, data collection and analysis were completed for a study of forest ecosystems of northern Vancouver Island and a similar study on the west coast of Vancouver Island.

The map of the Biogeoclimatic Units of Southwestern B.C. (Victoria-Vancouver map sheet - 92 SE; scale - 1:500 000) has been completed and the accompanying report is nearing completion.

Characterization of the most productive sites for the growth of commercial species in southwestern B.C. was continued with western hemlock and amabilis fir sites being studied.

Growth characteristics of stands with varying proportions of Douglas-fir and western hemlock on the mainland have been studied and the data is being analysed. These species will be studied on Vancouver Island in the near future.

Training courses in the use of ecosystem classification for tree species selection and site preparation were attended by over 200 Ministry and forest company personnel. These courses are presented annually in each of the nine Forest Districts within the region during the spring and summer.

ECOSYSTEM CLASSIFICATION IN THE NELSON FOREST REGION (E.P. 822.02) G. STILL AND M.V. KETCHESON

The end of the program sampling phase for mature seral and climax stands was reached with the completion of sampling in the ICHa1, 2, and reconnaissance in the as yet unfinalized ICHd. Analysis of plot data resulted in the delineation and finalization of the following subzone variants: ICHa1, ICHa2, IDFg1, 2, 3, and ESSFc. Completion of the sampling phase of the program facilitated the organization of our large data base. All vegetation data have been edited and all soil and site data were coded and entered on the B.C. Soil Information System (BCSIS). An author's draft of "A Field Guide for Identification and Interpretation of Ecosystems in the Nelson Forest Region" was printed and summarizes the final Braun-Blanquet style analysis of ecosystem associations of 14 subzones and subzone variants. It introduces the species/association table format of depicting the ecosystem associations of a subzone. The same information has been compiled and used to update the informal documentation, "Ecological Classification for the Nelson Forest Region (Third Approximation)".

The direction of future research activity within E.P. 822.02 will be toward the description of seral stages in the ICHa1 and ICHa2, brush hazard assessment in the ICHb, finalization of the ICHd, and investigations of ecological data with the objective of making wildlife interpretations.

Ecosystem classification training sessions were held in the following Forest Districts: Arrow, Boundary, Cranbrook, Golden, Invermere, Kootenay Lake, and Revelstoke. Crestbrook operational personnel were trained at Blue Lake. A new workshop in plant identification was given in Golden, Arrow, and Boundary Forest Districts.

ECOSYSTEM CLASSIFICATION IN THE KAMLOOPS FOREST REGION (E.P. 822.03) W.R. MITCHELL AND D.A. LLOYD

Field sampling and biogeoclimatic mapping for the ecosystem classification program continued in the PPBG, IDF, MS, ICH, and ESSF zones in the southeastern part of the Forest Region. First-approximation biogeoclimatic unit maps at a scale of 1:100 000 are available for field use.

An author's draft field guide for the identification and interpretation of ecosystems in the northeast part of the Forest Region is in preparation. First-approximation biogeoclimatic subzone maps at a scale of 1:100 000 are available for field use. A field guide for the identification of the common plants of the southern interior of British Columbia was published to assist in the identification of ecosystems.

Approximately 225 Ministry and industry personnel were trained in the identification and interpretation of ecosystems for use in forest and range management. In addition, approximately 25 foresters from Finland and 25 to 30 BCIT students were trained in the field application of ecosystem classification.

ECOSYSTEM CLASSIFICATION IN THE CARIBOO FOREST REGION (E.P. 822.04) W.J. WATT AND O.A. STEEN

Field sampling was completed for the SBSb subzone east of the Fraser River. Analysis of the data has resulted in splitting the previously mapped SBSb into two subzones, the SBSb and SBSk. The biogeoclimatic subzone map was updated to show the new boundary as well as to refine previous reconnaissance boundaries.

Progress was reported in three reports printed during the year. The first, "Classification and Identification of Ecosystems in the Cariboo Forest Region" is a comprehensive progress report and operational manual. Sections of this report describe ecosystem units and their management interpretations for six subzones. In addition, a condensed field guide of the manual was printed and distributed in the form of an author's draft. Finally, A Field Guide to the Sedges of the Cariboo Forest Region, British Columbia was prepared and published.

Training programs were conducted in each district to introduce Ministry and industry staff to procedures used to identify ecosystem units using the ecological field guide. Approximately 170 people were instructed during 12 half-day sessions. A one-day course on grass and sedge identification was presented to 10 Ministry staff. Two days of instruction in identification of range plants and range ecoystems were provided to 12 students enrolled in a U.B.C. course "Field Studies in Rangeland Resource" (Plant Science 320).

ECOSYSTEM CLASSIFICATION IN THE PRINCE RUPERT FOREST REGION (E.P. 822.05) J.J. POJAR

Data collection continued on schedule with field sampling concentrated in the CWH and CCPH zones of the Mid Coast, North Coast, and Queen Charlotte Timber Supply Areas. Field work for silvicultural interpretations was carried out primarily in the same areas. Field work is now largely completed for the primary study area (lower elevations of the southern half of the Prince Rupert Forest Region).

Review draft reports (including classification and interpretation) were prepared for the SBS zone and the CWHf subzone. Draft operational reports were produced for the CWH subzones of the Mid Coast (CWHh and i) and Queen Charlotte (CWHg) TSA's. The biogeoclimatic zones of the Cassiar TSA were described and mapped, and an interim classification of the BWBS was constructed. Classification correlation continued, especially with Vancouver Forest Region regarding northern Vancouver Island and adjacent areas. Correlation work was also conducted with the U.S. Forest Service in Southeast Alaska regarding coastal forests and grasslands.

With the assistance of other regional and headquarters ecologists and pedologists, the "Forest Ecology" section of the new fourth edition of the Forestry Handbook was compiled and edited.

Section 88-sponsored consultants finished ecosystem classification and mapping projects on Tree Farm Licences 24 and 39 on the Queen Charlotte Islands.

Training took place at regional headquarters and in the districts, and dealt with the SBS, ICHg, and CWHf, i, and g. Approximately 200 Ministry and industry personnel were trained by our full-time instructor and other research section staff resulting in 460 student-days of instruction.

ECOSYSTEM CLASSIFICATION IN THE PRINCE GEORGE FOREST REGION (E.P. 822.06)

A. MCLEOD AND G.HOPE

During 1982, field samplng was continued in the Prince George TSA. Sampling was completed in the SBSe2, SBSj and SBSf subzones and is nearing completion in the SBSb. Ecosystem associations were tentatively defined for these SBS subzones.

The author's review draft of the report on the low elevation subzones of the Rocky Mountain Trench (ICHb, f, k and j and SBSh) is near completion. Field work in the Fort Nelson TSA was completed and combined with the Ph.D. thesis of R.M. Annas as a report for use by District staff.

ECOLOGICAL INVESTIGATION OF WILDFIRES IN NORTHERN BRITISH COLUMBIA (E.P. 868)

D.V. MEIDINGER, J.J. POJAR AND R.L. TROWBRIDGE

The Research Branch contributions to this joint Research-Protection Branch study are nearing completion. The biogeoclimatic zones and selected subzones have been mapped in the Cassiar, northern Mackenzie and Fort Nelson TSA's, and reports describing these units are complete (Cassiar report) or near completion (northern Mackenzie and Fort Nelson). Interim classifications of the major ecosystems in two proposed variants and one subzone of the BWBS are being prepared.

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INVESTIGATIONS OF SOIL TEMPERATURES IN ECOSYSTEMS OF THE PRINCE RUPERT FOREST REGION (E.P. 920) R.L. TROWBRIDGE AND K. MCKEOWN

The object of this research is to help characterize subzones in the Prince Rupert Forest Region by their soil temperatures and to study the relationships of soil temperature in forested sites and clearings.

Twenty-one soil temperature/moisture plots have been established in the Prince Rupert Forest Region. At 14 of these plots, we have also established in conjunction with the Ministry of Environment, climate stations which measure continuous air temperature and monthly precipitation. These particular plots are being monitored in forest sites, as well as in adjacent clearings in order to establish relationships of soil temperature to forest canopy. Each plot will be monitored for three to four years to standardize the data, then the equipment will be rotated to new sites in other subzones.

In addition, a trial at the Telkwa nursery was established in order to become familiar with the CR-21 micrologger; and a selected reference list was prepared for the National Expert Committee on Soil Survey soil climate working group with particular attention to methodology. This list will be updated on an annual basis. A soil temperature program to graph data, calculate variables, and format suitable to SAS was developed and is at present being tested.

The data from this project were used at the Northern Silvicultural Committee summer workshop for demonstrative and instructive purposes, in the Regions' ecological reports, and in an upcoming chapter of Wetlands of Canada.

AN ECOSYSTEMATIC APPROACH TO SILVICULTURAL MANAGEMENT OF IMMATURE FORESTS (E.P. 930) R.N. GREEN

The study was initiated to provide resource managers with basic ecosystem information and interpretations. This information will be provided through the classification and integration of ecosystems of the Sayward Forest.

ECOSYSTEMS OF THE SAYWARD FOREST - THEIR DESCRIPTION AND INTERPRETATION (E.P. 930.01) R.N. GREEN

A demonstration of ecosystem mapping (scale - 1:10 000) was completed for the 1500 ha block between Pye and Stella Lakes in the northeast portion of the Sayward Forest. The ecosystem units were integrated to form an interpretive map of silvicultural treatment units. A report explaining the results and applications of ecosystem classification and mapping is in progress.

STAND DESCRIPTION AND MAPPING FOR OPERATIONAL PLANNING (E.P. 930.02)

R.N. GREEN

The stand map for the 1500 ha block referred to in E.P. 930.01 (scale - 1:10 000), and tables of stand attributes and recommended treatments, have been completed. A report explaining methodology and application is in progress.

A PROBLEM ANALYSIS OF GRASSLAND CLASSIFICATION (E.P. 931) A. NICHOLSON

The objective of the project is to report on the description and classification of grasslands and their incorporation into the Ministry of Forests ecosystem cassification program. A grassland ecology and classification symposium was held in Kamloops in June. Papers, discussions and field trips focussed on various aspects of the ecology and classification of grasslands in western North America. In particular, attention was directed to climate, surficial geology, soils, paleoecology, and vegetation. Proceedings of this symposium are available from the Queen's Printer Bookstore.

Two seasons of field reconnaissance sampling of southern grassland areas have been completed and the resulting data synthesized. Data assessment is near completion and a written report, including a description of the major ecosystems and recommendations, is being prepared.

ECOSYSTEM ASSOCIATION MAPPING IN THE TRUAX BASIN OF THE KAMLOOPS FOREST REGION (E.P. 942) W.R. MITCHELL AND R.D. WINKLER

The objectives are to develop a method for the mapping of ecosystems for use in the planning of environmentally sensitive areas, resource conflict areas, and subunit or development planning areas.

To accomplish the objectives an experimental pilot project was completed in Truax Basin in the Kamloops Forest Region. On the basis of this project, plus pilot projects in other Forest Regions, a method for the mapping of ecosystems is being developed.

An author's draft was completed for "Ecosystem mapping: a pilot project in Truax Basin in 1982", by W.R. Mitchell and R.D. Winkler.

INVESTIGATIONS OF ATMOSPHERIC AND SOIL CLIMATE IN THE DOME CREEK-MCBRIDE-VALEMOUNT AREA OF THE ROCKY MOUNTAIN TRENCH (E.P. 947) W. BLASHILL, G.D. HOPE AND A.J. MCLEOD

An atmospheric climate network was established in the area to investigate differences in the climate between subzones. Climate stations were set up in the three ICH subzones, the SBSh subzone, and in the ESSF Zone such that, together with Ministry of Environment stations, there are four stations in each subzone. At each station, air temperature, precipitation, and soil temperature at 50 cm depth are being measured. At two stations, solar radiation is also being recorded.

The M.Sc. thesis study of W. Blashill was established in the ICHj subzone near Valemount. This study will examine climate changes and seedling growth and development following logging in a mature cedar/hemlock forest.

OPERATIONAL BROADCAST BURNING - SITE PRODUCTIVITY TRIALS (E.P. 953) A. MACADAM

Prescribed fire is used extensively in the Prince Rupert Forest Region for the purpose of wildfire hazard abatement and as a tool for site preparation following clearcut logging. To date there has been little documentation of the short- and long-term effects of fire on the productivity of forest ecosystems under the range of conditions encountered in this region. This information is needed to ensure that fire use is consistent with the maintenance or enhancement of forest site productivity.

The purpose of this project is to investigate the response of some important soil properties and the performance of planted seedlings following operational broadcast burning. Four trials were established in 1982, including two in each of the ICHg and SBSe subzones. Site characteristics were recorded and soil samples were taken from three depth ranges for chemical and physical analysis. Pre- and post-fire fuel surveys and "depth-of-burn" pins provided a measure of slash and surface organic layer consumption. Fire weather indices, where available, were recorded to further document the burns. In 1983 these four sites will be planted operationally with spruce or pine seedlings, the soils will be resampled, and four additional trials initiated.

FOLIAR NUTRIENT STATUS OF FOUR TREE SPECIES IN THE KITIMAT VALLEY (E.P. 957.01) D. YOLE

Relatively little information has been collected in the Prince Rupert Forest Region relating to nutritional research. This project utilizes the experimental layout of E.P. 712, and was designed to compare foliar nutrient levels in lodgepole pine, Sitka spruce, western redcedar, and western hemlock in plantations established on six different landform/parent materials.

In the fall of 1982 foliage was collected from 1080 trees in 72 plots. Needle weight and tree heights were recorded for each tree sampled and foliar analysis is forthcoming for 12 nutrient elements.

Soil sampling will commence at the same plot locations in the spring of 1983. This will enable a comparison of soil and foliar nutrients for a range of landforms and tree species.

NUTRITIONAL INTERPRETATION OF FOREST HUMUS PROPERTIES G. DAVIS AND T.M. BALLARD

This study is a M.Sc. thesis research project to evaluate Douglas-fir stand nutrient status, by means of foliar analysis, and to determine its relationship to forest humus properties. Where forest humus data previously existed in 27 Douglas-fir stands in the Vancouver Forest Region, 265 trees were sampled for individual foliage sample analysis. Analyses for N, P, K, Ca, Mg, Mn, Fe, Zn, and Cu (and Al) have been completed. Analysis for S, B, and "active" Fe remains to be done. It was found that bud production significantly affected foliar nutrient concentrations.

AVAILABLE PHOSPHORUS IN FOREST SOILS T.M. BALLARD

A study has been established to find an adequate method of estimating "available" phosphorus in forest soil materials. The study involves a greenhouse pot trial with 8 soils x 2 P levels x 3 species x 4 replications. The soils were selected to provide a variety of soil properties, P forms, and P levels. The three species are Douglas-fir, western hemlock, and lodgepole pine. For each of the eight soils, 12 different methods of "available" P analysis have been used, and fractionation of some soil P forms (calcium phosphates, iron phosphates, aluminum phosphates) has been carried out. When seedlings are harvested (in 1983) soil P will be re-analysed and the soil data will be examined for relationships with seedlings phosphorus levels.

SILVICULTURE AND HARVESTING SUPPORT

The objective of this component of Ecology and Earth Sciences is to provide the physical, rather than the biological support information to research and operations in the silviculture and harvesting programs. Included are climate, hydrology, and slope stability studies.

Silviculture and tree growth studies receive the major portion of the climate research effort. However, climate is also an important component of the hydrology studies. These studies address the question of the impact of logging on domestic and agricultural water supplies. Slope stability projects identify factors causing mass wasting and characterize unstable terrain. Using this information, managers can reduce harvesting costs and the adverse impacts of logging on forest sites and fish habitat.

the three ICH subzones, the SBSh subzone, and in the ESSF Zone such that, together with Ministry of Environment stations, there are four stations in each subzone. At each station, air temperature, precipitation, and soil temperature at 50 cm depth are being measured. At two stations, solar radiation is also being recorded.

The M.Sc. thesis study of W. Blashill was established in the ICHj subzone near Valemount. This study will examine climate changes and seedling growth and development following logging in a mature cedar/hemlock forest.

OPERATIONAL BROADCAST BURNING - SITE PRODUCTIVITY TRIALS (E.P. 953) A. MACADAM

Prescribed fire is used extensively in the Prince Rupert Forest Region for the purpose of wildfire hazard abatement and as a tool for site preparation following clearcut logging. To date there has been little documentation of the short- and long-term effects of fire on the productivity of forest ecosystems under the range of conditions encountered in this region. This information is needed to ensure that fire use is consistent with the maintenance or enhancement of forest site productivity.

The purpose of this project is to investigate the response of some important soil properties and the performance of planted seedlings following operational broadcast burning. Four trials were established in 1982, including two in each of the ICHg and SBSe subzones. Site characteristics were recorded and soil samples were taken from three depth ranges for chemical and physical analysis. Pre- and post-fire fuel surveys and "depth-of-burn" pins provided a measure of slash and surface organic layer consumption. Fire weather indices, where available, were recorded to further document the burns. In 1983 these four sites will be planted operationally with spruce or pine seedlings, the soils will be resampled, and four additional trials initiated.

FOLIAR NUTRIENT STATUS OF FOUR TREE SPECIES IN THE KITIMAT VALLEY (E.P. 957.01) D. YOLE

Relatively little information has been collected in the Prince Rupert Forest Region relating to nutritional research. This project utilizes the experimental layout of E.P. 712, and was designed to compare foliar nutrient levels in lodgepole pine, Sitka spruce, western redcedar, and western hemlock in plantations established on six different landform/parent materials.

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DEVELOPMENT AND EVALUATION OF FOREST WATER BALANCE MODELS FOR USE IN STAND MANAGEMENT (E.P. 855) T.A. BLACK

Impact of Silvicultural Practices on the Water Balance of Douglas-fir

The objective of this research is to determine the effect of salal understory removal on tree water use, tree water relations, and growth in young Douglas-fir stands on drought-prone sites on the east coast of Vancouver Island. The research is taking place in a fertilized, thinned (820 stems/ha) Douglas-fir stand, planted in 1952, located 26 km northwest of Courtenay. Research at this site over the last eight years has shown that salal understory uses about 50% of the water available to the trees during the growing season (Figure 6, 7, and 8). In May 1981, four pairs of trees were selected for the salal removal experiment. The trees of each pair were very similar in size and were adjacent to one another. Salal was cut and removed from around one of each pair of trees. In the same year, the research showed that during a one-month dry period as much as 30 mm of additional water was transpired by the trees that had salal removed. In 1982, the root zone of each of the eight trees was isolated from those of its neighbours, using plastic sheeting buried to bedrock, in order to avoid error due to horizontal water movement. During the 1982 growing season, stomatal conductance and photosynthesis rates were measured on both trees of one pair during the day at 1-2 week intervals (Figure 9). Photosynthesis measurements were made using a $^{14}CO_2$-labelled air technique applied to individual needles. Photosynthesis rates of the tree with salal removed was significantly greater than that with salal present for much of the growing season. Pre-dawn twig water potentials were consistently higher (i.e. less water stress) in trees with salal removed in three of the four pairs of trees. The average values of basal area increment during 1982 of the trees with salal present and those with it removed were 5.9% and 8.2% respectively.

Figure 6. The rate of water use of salal understory is determined by measuring the stomatal conductance in a thinned Douglas-fir stand at Courtenay, B.C.

Figure 7. A microlysimeter is prepared for measuring the rate of evaporation from the soil from which salal understory had been removed in a thinned Douglas-fir stand at Courtenay, B.C.

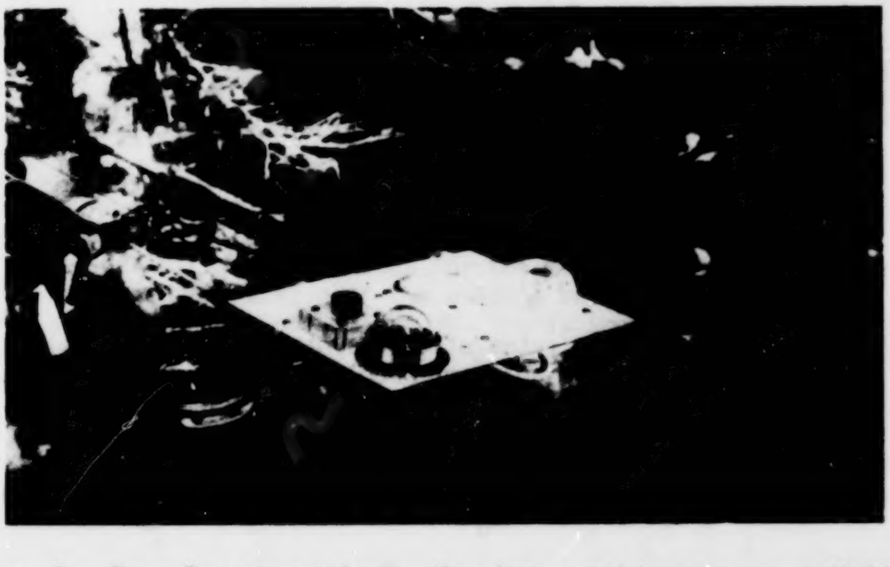

Figure 8. Tram for supporting radiometers used to measure radiation penetration through a thinned Douglas-fir canopy at Courtenay, B.C. From left to right - a net radiometer, a photosynthetic light (quantum) sensor and a solarimeter. The tram automatically moves back and forth along a 10 m long transect. The two heavy wires support the tram, while the light wires, driven by a small electric motor, pull the tram.

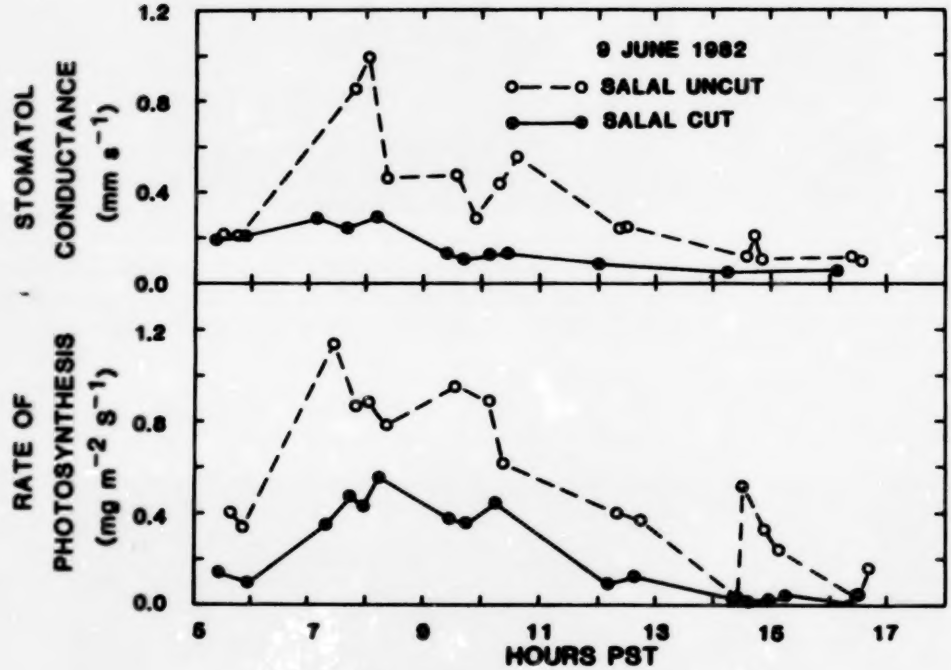

Figure 9. Comparison of the rates of photosynthesis and stomatal conductance of two adjacent Douglas-fir trees, one with salal understory, and the other with the salal cut and removed. The root zone water potential of the tree with salal present was -1.03 MPa (-10.3 bars) while that of the tree with salal removed was -0.69 MPa (-6.9 bars). Photosynthesis rate was measured by exposing needles to carbon-14 labelled CO_2 for 20 seconds.

COMPUTER MODELLING OF THE FOREST WATER BALANCE D.L. SPITTLEHOUSE

Computer simulations for the Courtenay site (E.P. 855) indicated large year-to-year variations in the degree of water stress experienced by the trees. This is a result of the large year-to-year variation in May-to-September rainfall. Root zone depth has a major effect through water storage. Preliminary analysis for three sites with 0.5, 0.75, and 1.0 m root zones gave average water deficits of 90, 57, and 39 mm respectively for the period 1965-1981. Yearly values varied from 0 to 200 mm. The respective site indices are 26, 27, and 41 m at 100 years, and average annual basal area increments (from cores) were 0.9, 1.1, and 1.7 m^2 per hectare per year. Individual yearly tree ring index was correlated with growing season transpiration (r^2=0.57).

SOIL WATER REGIMES ON A FORESTED SLOPE (E.P. 902) D.G. GILES AND T.A. BLACK

The quantitative evaluation of summer water stress over a range of sites on a forested watershed was accomplished by determining the soil water deficits occurring during the growing season. The relationship of soil water deficit to forest productivity was studied using site index, total stemwood volume, and annual incremental stemwood volume per unit area to quantify forest productivity at each site.

Two procedures were used for evaluating growing season soil water deficits. In the first procedure, deficits were calculated at each site during the growing seasons of 1980 and 1981 by summation of the weekly shortfalls of the actual transpiration rate (limited by available soil water storage) below the maximum transpiration rate (limited by the weather). The second procedure for calculating growing season soil water deficits was by monthly water budgeting over the growing season of each year from 1964 to 1981, for which years the required climatological data was available.

Growing season soil water deficit variations between sites for 1980 and 1981 were found to be well correlated with forest productivity as quantified by site index (Figure 10) and by total stemwood volume. Relative differences in soil water deficits between sites for the years 1980 and 1981 were thus concluded to be representative of the average relative site-to-site differences over the life of the stand. Yearly incremental stemwood volume for 1964-1981 was also found to be well correlated with growing season soil water deficit.

UPPER PENTICTON CREEK EXPERIMENTAL WATERSHED STUDY (E.P. 956) J. CHENG

The objective is to assess quantitatively the hydrologic effects of watershed logging (clearcut and small openings) and modify the current integrated resource management guidelines and prescriptions if appropriate. The working plan has been finalized and three study watersheds selected. Access roads to two of the selected streamflow gauging sites were constructed in November 1982.

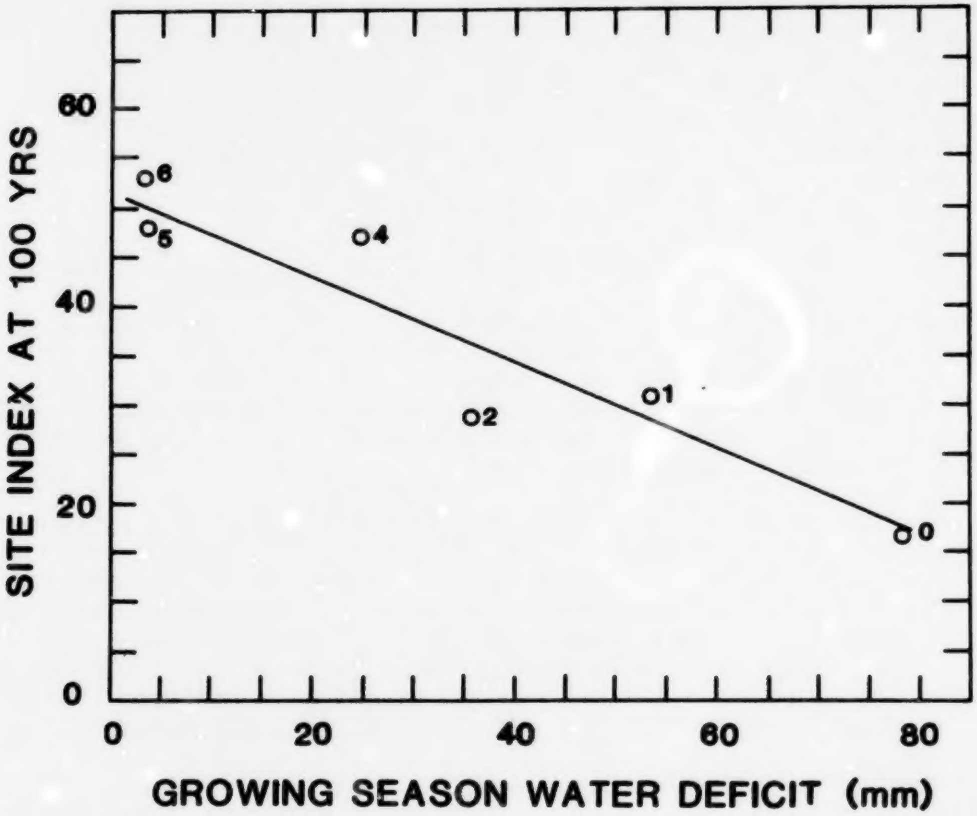

Figure 10. Site index at 100 years compared with site growing season water deficit in 1981 (Site numbers are adjacent to the points).

RAIN-ON-SNOW HYRDOLOGY IN THE QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA (E.P. 959) D. WILFORD

The problem analysis and working plan were completed in 1982. A set of plots were established to measure snow melt in a clear cut and in an old-growth forest. Climatic data were collected, using electronic dataloggers, in order to calculate snow melt using the USACE equations. These calculations will be compared with actual melt measured with snow melt lysimeters. Output from these 15 m^2 lysimeters was determined with a specially designed tipping bucket connected to the datalogger. A heated, insulated box was constructed to assure good data collection during adverse weather conditions. The equipment was operated from November 1982 to March 1983 and will be used again in winter 1983/84.

SNOW ACCUMULATION AND MELT ON FORESTED AND CLEARCUT SITES IN THE WEST KOOTENAYS, BRITISH COLUMBIA (E.P. 967) D.A.A. TOEWS AND D.R. GLUNS

In the Nelson Forest Region, the accumulation and subsequent melting of snow is a major component of streamflow generation and consequently dominates the annual hydrograph. Thus, changes in the quantity and timing of streamflow within any particular watershed may be altered by timber harvesting. A synoptic survey of 29 paired clearcut and forested sites on various aspects and elevations was initiated to determine the difference in maximum snow accumulation between forested and clearcut sites typical of the southern portion of the Nelson Forest Region. Also, measurements of net losses of snow were undertaken on five forested/clearcut pairs to determine the differences in melt rates between forested and clearcut sites.

An initial objective of these studies is to determine the applicability of research results and guidelines for watershed management done elsewhere. In particular are those studies done by H.F. Haupt in the area of northern Idaho to southeastern B.C. The synoptic survey will continue for three years. A second phase of the study will involve instrumenting several pairs of forested and clearcut sites with meteorlogical equipment and lysimeters to gain a better understanding of the processes of snowmelt causing the changes between forested and clearcut sites.

SLOPE STABILITY ON THE QUEEN CHARLOTTE ISLANDS (E.P. 782) J.W. SCHWAB AND D.J. WILFORD

The preliminary findings of this slope stability research project on the Queen Charlotte Islands were used in developing the problem analysis and recommendations for the Fish Forestry Interaction Research Program. Specific experimental topics identified for research have now been incorporated into the physical study component of E.P. 862.

A literature review was prepared under contract by R.T. Pack dealing with three separate but closely allied topics of importance to slope stability problems on the Queen Charlotte Islands: factors controlling debris torrents (flows); techniques for forest road construction through unstable terrain; and slope stability mapping and hazard rating systems for forest land. The selected annotated bibliography places emphasis on papers dealing with physiographic settings similar to the Queen Charlottes. The paper will be prepared for publication in 1983.

MASS WASTING CAUSED BY THE OCTOBER-NOVEMBER 1978 STORM, RENNEL SOUND, QUEEN CHARLOTTE ISLANDS (E.P. 782.02) J.W. SCHWAB

Data was collected on 264 failures, triggered by a single storm event estimated to have a return period of less than 10 years. Mass movements occurred at a frequency of $0.8/km^2$ in forested terrain, $11.6/km^2$ in clearcuts, and $20.8/km^2$ from roads. The rate of mass wasting averaged for man-modified terrain is 15 times greater than forested terrain. Failures in clearcut units contribute the largest accelerated mass wasting impact in terms of total land area modified by logging operations.

THE SEDIMENT STORAGE FUNCTION OF LARGE ORGANIC DEBRIS AT THE BASE OF UNSTABLE SLOPES (E.P. 782.03) D.J. WILFORD

The objective of this study was to determine the storage role of large organic debris in old-growth Sitka spruce - western hemlock forests, in providing an important sediment storage element on the slope. As the old growth trees fall or blow down across the slope, they form a series of cross-slope obstructions. Sediments and small organic debris from upslope mass movements are deposited behind these obstructions, forming a series of terraces which temporarily delay sediment delivery to stream channels.

WILDLIFE HABITAT RESEARCH

R. Ellis, Program Manager

Every Timber Supply Area plan in the province is affected by wildlife, and preserving areas of old growth as ungulate winter range has a significant impact on the annual allowable cut. Wildlife and old growth require management decisions now. However, they also require research to determine if forest harvesting practices, timing, or scheduling can be altered to allow forest harvesting and management, and yet retain the usefulness of the habitat for wildlife. The Wildlife Habitat Research program is designed to provide information to make these harvesting and management decisions.

As we concentrate more on managed forests, the kind of management will determine how useful these new forests will be for wildlife habitat. Research will tell us how and when, over a forest rotation, wildlife habitat for various species can be created or protected. This research involves the consideration of many wildlife species and it is important that we be involved as it includes the bulk of the forest landscape.

The Wildlife Habitat Research Program is carried out in co-operation with the Ministry of Environment.

HABITAT RELATIONSHIPS OF MULE DEER IN THE INTERIOR DOUGLAS-FIR ZONE OF CENTRAL BRITISH COLUMBIA (E.P. 903) H.M. ARMLEDER

Mule deer habitat relationships are being investigated in an effort to determine a means of integrating forest and wildlife management. Significant progress was made during the past year toward meeting project objectives.

Data collected during the winter of 1981/82 were analysed, and revealed the relative importance of major habitat types within winter ranges. Old-growth fir consistently received the greatest use. Habitat use during 1982/83 was markedly different because of the lack of snow and mild temperatures.

Fourteen deer fitted with radio-transmitters were located during all months of the year. These data highlighted the importance of small key winter ranges to mule deer summering over vast areas. The spatial relationships between seasonal ranges were also identified.

A timber harvesting system for mule deer winter ranges was developed and will be tested on a 25-hectare experimental block. The system involves a low-volume harvest of marked trees in micro habitats least important to deer on a winter range.

Research results were applied to improve integrated resource management. Mule deer winter range maps were produced for the Williams Lake Strategic Planning Unit with the co-operation and assistance of the Fish and Wildlife Branch.

ROOSEVELT ELK/INTENSIVE FORESTRY INTERACTIONS (E.P. 912) D.W. JANZ (Ministry of Environment)

The major objective of this project, initiated under the Integrated Wildlife - Intensive Forestry Research (IWIFR) program, is to assess the response of elk habitat and numbers to various silvicultural treatments. Research on elk ecology and interactions with intensive forestry is required to provide the biological information necessary for effective integrated resource management.

Progress on the study included: 1) tests of radiotelemetry accuracy to determine limitations of the system in use; 2) food habits and animal condition assessments from fecal analyses collected in all seasons and from all herd areas; 3) data analysis from 11 permanently established weather stations to assess differences in temperature and rainfall in habitat types differing in history of silvicultural treatment; and 4) three 5-day intensive monitoring radiotelemetry sessions which were carried out to determine summer range habitat use. Cow to calf ratios for all herd areas were determined from late summer aerial survey flights and five 4-day intensive radiomonitoring sessions generated 194 locations spread throughout the 24-hour period of a migratory cow occupying a winter range in intensively managed regenerating forest habitats. All habitats within the winter range of the intensively monitored animal were assessed by determining forage availability and canopy cover in 556 plots. Animal activity, temperature, and wind parameters were continuously recorded throughout the intensive monitoring periods. Also, twenty hunter-supplied samples from elk killed in the study area were analysed to determine pregnancy rates and animal condition. Monthly radiolocations and pellet group collections were gathered from all herd areas.

LANDSAT IMAGE CLASSIFICATION SYSTEM AS A WILDLIFE HABITAT CLASSIFICATION SYSTEM (E.P. 913) K. SADOWAY

Three Landsat image classification methods were compared as part of the IWIFR program on Vancouver Island. Each Landsat image format (paper print, positive transparency, digital computer tape) was used to develop a cover type classification map. A comparative evaluation of costs, accuracy, precision and utility of the classification system with respect to wildlife habitat application was conducted, and a final report was prepared.

EFFECTS OF INTENSIVE FOREST MANAGEMENT ON NON-UNGULATE WILDLIFE (E.P. 916)
K. SADOWAY

The objective of the probelm analysis was to define research questions and priorities regarding habitat needs of non-ungulate wildlife on Vancouver Island, and, as part of the IWIFR program, to study the effects of intensive forest management on these species.

The problem analysis has been divided into three sections: amphibians and reptiles, mammals, and birds. Each section includes a problem reference, species habitat/life history information, wildlife-forestry interaction information, and recommended research topics designed to address information gaps.

The following reports were prepared by V. Bianci:

1. A bibliography of the wolverine _Gulo gulo_
2. The wolverine in British Columbia: distribution, methods of determining age and status of the Vancouver Island subspecies (_Gulo gulo vancouverensis_).

INTENSIVE FORESTRY EFFECTS ON VANCOUVER ISLAND BLACK-TAILED DEER (E.P. 923)
R. DAVIES (Ministry of Environment)

The objectives of this study, a component of the Integrated Wildlife Intensive Forest Research (IWIFR) project on Vancouver Island, are:

1. to examine the effects of silvicultural activities on deer habitat utilization and deer populations;
2. to examine present conceptual models of how deer use and select winter habitat in existing mature- and second-growth forests in response to snow conditions and forage availability;
3. to test deer habitat selection models via active habitat manipulation on deer winter range and spring foraging areas; and
4. to investigate the effects of silvicultural treatments on population size, productivity, survival, and dispersal.

Accomplishments in 1982/83 include: 1) completion of a problem analysis and working plans; 2) field work on deer winter habitat selections initiated in the Nanaimo River drainage and the Sayward Forest; 3) the capture of 32 deer which were radio collared and monitored throughout the year (24 in Nanaimo River and 6 in Sayward Forest); 4) weekly monitoring of 20 of the 32 deer to determine seasonal range and habitat use patterns (800 locations were obtained); and 5) the intensive monitoring of 12 deer (every two hours for a one-week period twice during mid-winter) to obtain winter habitat selection data (1 200 locations).

Since snow accumulations were minimal this winter, data will only provide information for mild to moderate winter habitat use. Lack of snow also prevented any hypothesis testing of deer response to snow and associated forage availability.

Eight deer mortalities occurred, mostly due to wolf predation. Wolf control was initiated in the Nanaimo River area and six wolves were removed. No deer mortalities have occurred since.

Plots were established in the Nanaimo River study area to assess snow and forage conditions and deer use. Weather stations were also located in conjunction with E.P. 934. Due to lack of snow only pellet group and weather data were collected. Baseline deer population status and productivity were assessed using spring and summer deer counts, and deer hunter harvest information.

INTENSIVE FORESTRY EFFECTS ON VANCOUVER ISLAND DEER AND ELK HABITATS (E.P. 934) J.B. NYBERG

A problem analysis with recommendations for research topics and study areas was completed. Working plans were finalized for studies of forage and snowpack responses to intensive silviculture practices. Thinning and fertilization experiments, being conducted by government, forest companies, and universities, were surveyed to determine their suitability for investigations of deer and elk habitat values. This project is part of the IWIFR program.

During the field season 82 plots were sampled from May to October for EP 934.01. These plots assessed understory cover responses to thinning and fertilization in stands older than 20 years at the time they were thinned, and covered half of the combinations of biogeoclimatic subzones and sites that were planned for sampling. Canopy photography was completed for most plots. Elk habitats in a portion of the Salmon River drainage were mapped for use in analysing radiotelemetry data from EP 912.

For the winter range project (EP 934.02), a sampling network for assessing deer use, snow forage, and overstory characteristics in a variety of stand types was prepared in two areas of the Nanaimo River watershed. Due to the mild winter, snowpacks in the area never reached the minimum depths required for the planned sampling program. Assistance was provided to the IWIFR deer project in monitoring the movements of transmitter-equipped deer, but habitat work was postponed until next winter.

For the IWIFR elk project (EP 912), habitat assessments were conducted following five 4-day sessions of intensive radiotelemetry monitoring. Forage, snow, and overstory closure were measured in each habitat type used by the transmitter-equipped animal during each 4-day period. Weather patterns were monitored in the study area with CR-21 weather stations.

CARIBOU-FORESTRY INTERACTIONS IN BRITISH COLUMBIA (E.P. 939) S.K. STEVENSON AND D.F. HATLER

This project constitutes a review of caribou distribution, population status, and general biology in relation to forestry practices, past and projected, over the southern half of the province. The ultimate objective, following this review, is the design of a broad-based long-term research program to better describe, if not resolve, the inherent conflict in our attempt to produce both wood and a "climax" wildlife species - caribou, in the same area.

Review of published literature, examination of unpublished data in provincial government files, and interviews with wildlife and forest managers have been completed. An analysis of forest status within identified caribou ranges, based on Inventory Branch data, is underway. This body of information allows identification of research questions and methods, and addresses the problem of selecting priority areas for research and management.

AN EVALUATION OF SAMPLING AND ANALYSIS SYSTEMS FOR WILDLIFE HABITAT ANALYSIS (E.P. 950) R.E. PAGE

In an effort to develop a sampling methodology for wildlife habitat research projects, personnel from EP's 896, 903, 912, 923, 937, 939 and 952 were contacted regarding their sampling problems and possible solutions. Consultations were also conducted with staff from all B.C. universities. A report entitled "Technological Concerns in the Use of Radio Telemetry for Animal Habitat Identification" was produced.

Additionally, a standard Field Radiolocation Data Form and a new method of determining locations of animals using error angles have been implemented, increasing accuracy and producing provincially standardized computer output files. Also, a series of null antenna towers was installed on the Knife Creek Mule Deer winter range (E.P. 903) with the assistance of Electronic Services, Technical Services Branch, both to increase accuracy of radio locations in that study and as a demonstration of the technique.

WILDLIFE HABITAT HANDBOOKS FOR THE FORESTS AND RANGELANDS OF B.C. AND ASSOCIATED PROJECTS: KAMLOOPS PILOT PROJECT (E.P. 951) A.P. HARCOMBE

The wildlife habitat handbook pilot project for Kamloops was initiated after Andrew Harcombe of the Terrestrial Studies Unit, Surveys and Resource Mapping Branch, Ministry of Environment, was assigned as regional project co-ordinator. The steering committee provided an initial project outline (with objectives) for the development of a problem analysis which is well underway.

Dr. Hal Salwasser, Ecologist, USDA Forest Service, and national co-ordinator for the wildlife-habitat relationships program in the United States, provided advice and direction for the project at a planning workshop held in B.C. Some preliminary collaboration with specific wildlife-habitat research programs is taking place.

COASTAL GRIZZLY BEAR - FORESTRY INTERACTION RESEARCH PROJECT (E.P. 952) W.R. ARCHIBALD AND T. HAMILTON (Ministry of Environment)

Field research was initiated in 1982/83 in the Kimsquit watershed. Despite a shortened field-season, important accomplishments were made with radio transmitters being affixed to 10 grizzlies. Field techniques were developed and data acquisition initiated.

The working plan was prepared, but not finalized, in 1982/83. An analytical model is being developed.

Staff from the Research Section, Prince Rupert Forest Region, completed a preliminary ecosystem classification of the study area. The final classification will provide the basis for habitat description and analysis.

FISH/FORESTRY INTERACTION

V. Poulin, Program Manager

Timber harvesting on marginally stable terrain on the Queen Charlotte Islands has accelerated the rate of soil mass movements. In areas of intensive mass wasting, yarding disturbance and road construction has significantly increased the volume of sediment and debris delivered to important sport and commercial fish streams. Although the effects of mass wasting on forest site loss and fish habitat are uncertain, current land management practices are curtailing logging in steep lands susceptible to mass wasting. Reductions in current annual allowable cut reflect these measures. Protection of the forest land base will continue to be justified until information is available describing the impact of mass wasting on fish production and forest growth, or until it can better be determined where and how to log steep slopes in an environmentally acceptable manner.

FISHERY/FORESTRY INTERACTION IN AREAS OF INTENSIVE MAN-WASTING (E.P. 862)

V. POULIN

In 1981 the Fish/Forestry Interaction Program was initiated to undertake field research in areas of fisheries biology, fluvial geomorphology, photogrammetry, and forest growth, to define the extent and severity of mass wasting on the Queen Charlotte Islands and determine the impact of mass movements on fish habitat and forest productivity. Various prescriptive studies have been undertaken to help provide management options and solutions for logging steep, marginally stable terrain. Areas of investigation include alternative harvesting systems, logging planning, silviculture, and forest site rehabilitation. Within the stream environment several in-stream restoration techniques have been tested that have potential for improving fisheries habitat in streams destabilized by mass movements.

During the 1982/83 fiscal year, four major studies were initiated which involved 13 subcomponent studies. These include:

1. SYNOPTIC SURVEY OF WATERSHEDS (E.P. 862.2) - This is a group of research initiatives addressing the impact of landslides and subsequent soil erosion on the productivity of both fish habitat and forest land, and is comprised of the following studies:

    i. Watershed modelling, Tom Chamberlin (MOE participant)
    ii. Landform analysis, Lee Beaven (FFIP)

iii. Regional landslide overview, Phil Gimbarzevsky (CFS participant)
iv. Landslide inventory from large scale photography, Ken Rood (FFIP)
v. Channel morphology, Dan Hogan (FFIP, U.B.C.)
vi. Major fluvial disturbances, Bert Roberts (FFIP, U.B.C.)
vii. Fisheries investigations, Ted Harding (FFIP)
viii. Forest growth investigations, Dick Smith (CFS participant)

2. STREAM AND FOREST REHABILITATION STUDIES (E.P. 862.3) - These studies are directed at identifying ways to restore and improve the productivity of streams and forest land that have been affected by landslides. They include:

    i. Gabion evaluation, Herb Klassen (FFIP, U.B.C.)
    ii. Large organic debris emplacement, Derek Tripp (FEBAP)
    iii. Forest rehabilitation, Bill Carr and Chris Marchant (MOF/FFIP)

3. SILVICULTURAL INVESTIGATIONS (E.P. 862.4) - The 1982/83 study is a review of forest management techniques that can be used to maintain and improve slope stability and lessen the chance of landslides. Peter Sanders (U.B.C.) is the project leader.

4. ALTERNATIVE LOGGING STUDIES (E.P. 862.5) - These studies are directed at examining different planning and logging methods that would lessen the chance of landslides. Project leaders are Mike Nagy and Tony Sauder (FERIC).

The following sections describe more fully the purpose and objectives of the research components being undertaken.

1. SYNOPTIC SURVEY OF WATERSHEDS (E.P. 862.2) Watershed Modelling/Long Term Climate Trends T.W. CHAMBERLIN

The purpose of this study was to develop a stratification methodology that will permit extrapolation of study results to unsampled basins on the Queen Charlottes and elsewhere where similar terrain characteristics may be found. The first-stage regional level stratification has been completed resulting in the identification of nine broad geographical units having similar properties. A second-stage stratification procedure is being developed to describe drainage basin areas having similar morphometric characteristics, and to permit comparative analysis of study results. In addition, climate records are being compiled to determine long-term climate trends that may have influenced the rate of mass wasting on the Queen Charlottes over the period of records.

2. SYNOPTIC SURVEY OF WATERSHEDS (E.P. 862.2) Landform Analysis L. BEAVEN

Detailed case studies of specific mass wasting events of different types are being compiled. These studies include estimates of material that was displaced, estimates of how much of it entered a stream, and an attempted tracing of the movement of this "slug" downstream. Slope, rock type, depth of weathering, surficial material, aspect, land use, relief, preceding weather, and failure type are all being documented to try to ascertain which parameters most influence distance of travel of mass wasting. A sampling network of recording stream gauges and rain gauges has been established to estimate the variations in response of local drainage basins and fluvial systems to specific precipitation inputs. Detailed case studies of new and dated mass wasting events are supplying information that provides insights into relative rates of stream recovery. The assessment of impacts, both acute and chronic, of various sizes and types of mass wasting events that have entered stream systems has been started. These studies are designed to determine the magnitude of the stress, the stream's response, and the duration of the perturbation.

3. SYNOPTIC SURVEY OF WATERSHEDS (E.P. 862) Synoptic Survey of Mass Wasting Processes From Small-Scale Aerial Photography P. GIMBARZEVSKY

Information describing the extent and frequency of mass wasting on the Queen Charlottes is essential for understanding both the implications of harvesting marginally stable terrain, and the potential impact on forest and fishery resources. This project was undertaken to provide a regional survey of slope failure events based on analysis of 1979-1980 small-scale (1:50 000) aerial photographs.

Stage I of a two-part study has been completed. This has included the rapid analysis of most recent small-scale aerial photographs and compilation of a synoptic overview map showing the location and density failure features.

In Stage II, large scale patterns of mass wasting will be related to site and external variables including rock type, terrain features, vegetation, logging history, and climate. All analyses of early aerial photographs (1933-1982 photography) are being undertaken to compare slope failure development over time with logging and major seismic events.

4. SYNOPTIC SURVEY OF WATERSHEDS (E.P. 862.2) Landslide Inventory From Large Scale Photography K. ROOD

To describe the linkage between forest harvest activities and the potential damage to fish resources and loss of productive forest area by mass wasting, the relationship of land use to occurrence of mass movements was examined using large-scale (1:10 000) color aerial photography. The inventory will provide detailed photogrammetric analysis of failure site characteristics in 31 basins included in the Synoptic Survey of Watersheds. To date, a total of 964 failures have been examined. Of these 40% occurred in logged (36.2 km^2) terrain, and 550 in unlogged (190.1 km^2) terrain. This represents an average failure frequency of 3.4/km^2. The relationship of slope failures to forest harvesting activity is also being examined. Failures in logged areas are classified according to source of origin - clearcut/open slope, clearcut/open slope yarding, clearcut/road fill, and clearcut boundary failure. Potential affects on downstream resources is being quantified on the basis of volume of sediment delivered to streams, stream lengths, and forest area affected. Slope failure data from this study will be analysed to determine the potential for developing a probability of risk model for landslide occurrence in unlogged terrain.

5. SYNOPTIC SURVEY OF WATERSHEDS (E.P. 862) Morphological Characteristics of Logged and Unlogged Streams D. HOGAN

Coastal cobble- and gravel-bed streams exhibit characteristic channel and flow conditions. These are a function of flow regime and sediment input. If either of these factors is altered, the channel must adjust to the imposed conditions. This may have adverse consequences on fish habitat. The nature and extent of channel adjustment resulting from logging activity is not well understood on the Queen Charlotte Islands. This study was undertaken to characterize the channel morphology of streams flowing over logged and unlogged watersheds. The project will provide detailed geomorphic data describing longitudinal and cross-sectional channel shapes, storage, volume, and size distribution of both elastic sediment and large organic debris material and flow conditions. This information will supplement fish habitat quantification being undertaken by other FFIP researchers, and assist in the design, placement, and evaluation of stream restoration structures. This study is being undertaken as a post-graduate study in the Department of Geography, University of British Columbia.

6. SYNOPTIC SURVEY OF WATERSHEDS (E.P. 862) Major Fluvial Disturbance in Logged Watersheds R.G. ROBERTS

Some creeks in the Queen Charlotte Islands exhibit large sediment accumulations in their mid-reaches. These deposits result in significant loss of fish habitat through dewatering and alienation of upstream habitat and may be a consequence of logging activity in these watersheds. This study examines the sources, causes, mobility, and impacts these accumulations have on the fluvial environment.

Morphologic investigations of these deposits indicate that, in long profile, they are in the form of a sediment wedge, and in plan view they have a depositional zone whose width is an order-of-magnitude greater than that of the stream channel. Estimates of the volume of bank material eroded since logging and the volume of sediment stored in the wedges are comparable. This implies that the sediment contribution from mass wasting is subordinate to the input from streambank erosion. The poor sorting and lack of stratigraphy in the sediments suggest that, once introduced, they are not transported far, and that the wedges are, therefore, temporarily immobile.

These results suggest that there is a "cumulative" impact on watersheds from logging practices, and hence, there is the need to gain an understanding of various processes acting on stream systems in order to isolate impacts due to mass wasting. This study is being undertaken as a post-graduate study in the department of Geography, University of British Columbia.

7. SYNOPTIC SURVEY OF WATERSHEDS (E.P. 862.2) Fisheries Investigations

T. HARDING

Harvesting timber on marginally stable terrain has accelerated the rate of mass soil movements on the Queen Charlotte Islands and increased the volume of debris entering productive salmon and trout streams. While extensive research has been undertaken into the effects of logging, little is known of the effects of mass wasting on fish populations and fish habitat.

Field work has been undertaken in over 40 Queen Charlotte Island streams to provide information describing the distribution and abundance of fish and habitat conditions in streams affected by mass wasting. Emphasis has been placed on quantifying the effects of mass wasting on habitat quality as expressed in pool and riffle sequence, amount and distribution of large organic debris, gravel composition, stablity, and changes in fish population dynamics. Preliminary results of this study suggest that debris torrents result in long-term damage to fish populations and fish habitat, and that rate of natural recovery may be slow. In logged areas recovery could be further delayed due to the lack of recruitment of large organic debris. Results of gravel quality analysis suggest lithology is a factor in influencing the amount of sediments in stream gravel, but no significant correlations could be observed between logged and unlogged basins. Gravel scour due to extensive deposits of unconsolidated bed material appears to be emerging as a possible major limiting factor to fish production in many streams.

Ongoing studies are directed at determining rate of recovery of fish habitat, assessing overwinter survival of fish in streams damaged by mass wasting, and studying gravel stability.

8. SYNOPTIC SURVEY OF WATERSHEDS (E.P. 862.2) Forest Growth Investigations D. SMITH

Forest growth studies have been completed on 45 landslides ranging in age from 1 to 125 years to determine effects on forest productivity. Data describing soil depth, rate of vegetation establishment (% cover), vegetation succession, and soil development are compared with slide and adjacent non-slide terrain. Extensive analysis of the available data is yet to be completed. However, distinctive trends in the parameters measured are apparent and have been reported.

9. STREAM AND FOREST REHABILITATION STUDIES (E.P. 862.3) Improving Spawning Habitat Using Gabions H. KLASSEN

This study was undertaken to evaluate the effectiveness of gabion weirs in producing stable spawning habitat for pink and chum salmon in landslide-damaged creeks. Gabions were installed at three treatment sites in Sachs Creek. Post-installation analysis of treatment and control sites include monitoring of adult utilization, egg-to-fry survival, gravel stability, and streamside recovery of bank conditions. Preliminary results indicate conditions and cost/benefit could be low. This study is being undertaken as a post-graduate program in the Department of Forestry, University of British Columbia.

10. STREAM AND FOREST REHABILITATION (E.P. 862.3) Fish Habitat Restoration Using Large Organic Debris D. TRIPP

Debris-torrented streams which lack stable large organic debris (trees, root wads, large woody pieces) tend to be simple streams with comparatively few fish-spawning and rearing areas. Fish production is generally reduced until the stream recovers. In small streams the period of recovery may be very long in the continued absence of stable large organic debris (LOD).

This project was initiated to assess the feasibility of using LOD to restore stream habitat damaged by mass wasting and to compare the costs of other rehabilitation techniques. Twenty-five pieces of debris were placed in an experimental section of Southbay Dump Creek located on Moresby Island. Replacement and post-placement evaluations included stream mapping of pool-riffle boundaries, channel thalweg, stream edges, banks, and location of LOD. Summer low flow and overwinter population estimations were calculated and downstream smolt trapped to document smolt production in control and experimental sections.

Although peak spring flows continue to modify treatment sites, preliminary observations suggest that habitat complexity is increasing. While all placements are not contributing to accelerated stream recovery, a definite pattern of increased pool area and meander length is emerging. The use of LOD looks promising for future stream rehabilitation on the Queen Charlotte Islands. This study was initiated as a FEBAP project.

11. STREAM AND FOREST REHABILITATION (E.P. 862.2) A Review of Hillslope Restoration Techniques W.W. CARR

A review of watershed rehabilitation options to reduce soil erosion on landslide scars was undertaken to suggest possible options for study. Research into the transfer of bio-engineering technology to the Queen Charlotte Islands was suggested. As well, the basic steps necessary for implementation of a rehabilitation planning program were discussed. In addition, approximately 7000 shrubs were propagated for use in pilot studies.

12. SILVICULTURAL INVESTIGATIONS (E.P. 862.4) Silvicultural Alternatives for Improving Slope Stability P. SANDERS

A literature review was completed to identify alternative silviculture methods that offered research opportunities in 1983/84 for improving soil stability through the establishment of thrifty root systems on logged slopes. Two pilot studies were suggested. The first would examine time-of-year cutting as a factor in residual root strength. The second would study root egress of natural versus planted stock (plug and root prune stock), to determine possible improvements in planting stock selection.

13. ALTERNATIVE HARVESTING STUDIES (E.P. 862.5) M. NAGY AND T. SAUDER

The alternative harvesting studies have two components. The first, a logging planning study, involved extensive field work this past summer to provide forest engineering data to enable evaluation of various planning methodologies that recognize and mitigate for steep slope logging problems. Field work was completed on three study sites and work is in progress to complete the office phase. The second aspect of the logging studies is the examination of alternative harvesting systems for steep slope logging. A literature review of the influence of forest harvesting practices on mass wasting was undertaken to determine the major factors contributing to landslides in man-modified terrain. This review notes that road construction and location are the greatest contributors to harvesting-related failures. Alternative harvesting systems which offer the greatest potential for reducing mass wasting are those which reduce amount of road and debris accumulations and are compatible with silviculture needs; allow the best distribution of yarding roads; and avoid pulling anchor stumps. Experimentation with alternative systems has not been initiated to date.

RANGE RESEARCH

B. Wikeem, Program Manager

The livestock industry in British Columbia contributes significantly to the social and economic well being of British Columbians. In 1978 an estimated 92 million dollars was generated from farm cash receipts for cattle sales and the outlook over the next decade is for further expansion of the industry.

Crown range, administered by the Ministry of Forests, is of fundamental importance to the livestock industry in B.C. by providing spring, fall, and summer forage to mainly cow/calf operations. In 1980, a new record of 930 000 animal unit months or 60% of the total forage requirement of the ranching industry was provided by Crown Range yielding revenues amounting to 1.3 million dollars.

Only recently has the need been recognized for a Range Research program within the Ministry. The Research program will provide information to solve range management problems confronting ranchers and government staff.

RANGE RESEARCH NEEDS FOR BRITISH COLUMBIA (E.P. 954) B. WIKEEM

The objective of this problem analysis is to recommend specific range research programs that will assist in providing information for range resource managers in B.C. Relevant literature has been compiled and an overview of past research efforts in the province summarized. Interviews with key resource agency personnel are complete.

A SELECTED BIBLIOGRAPHY ON RANGE FORAGES AND LIVESTOCK MANAGEMENT IN BRITISH COLUMBIA (E.P. 954.01) B. WIKEEM

Over 1400 citations on all aspects of range, forages, and livestock management in British Columbia have been compiled for editing. Key words will be assigned to all references in the completed publication. This report will provide resource managers with a useful tool to quickly locate literature on B.C. rangelands.

RANGE FERTILIZATION (E.P. 861) B. WIKEEM

In co-operation with the B.C. Cattlemen's Association, Agriculture Canada, the Ministry of Agriculture and Food, the Ministry of Environment, and Ministry of Forests Range Management Branch, the Range Fertilization Project comprises five concurrent studies aimed at evaluating the biological and economic effects of fertilizing both grassland and forested range. The five studies are: 1) date of fertilizer trial; 2) commercial aerial application of urea; 3) rate of fertilizer trial; 4) type of fertilizer trial; and 5) assessment of range fertilization using large-scale 35 mm color aerial photographs. They were initiated in 1981 and sampling continued in 1982.

PROBLEM ANALYSIS: INTERACTIONS AMONG FORESTRY, RANGE AND WILDLIFE MANAGEMENT IN THE EAST KOOTENAYS (E.P. 936) M.D. PITT AND A. ALLAYE CHAN

The final report summarized the major problems and recommended appropriate research. Philosophical and technical disagreement over the proper allocation of available forage production between elk and domestic livestock was considered the central issue. Forest ingrowth and succession also contribute to declining forage availability. A research program was recommended to determine the impacts of cattle grazing on forage quality and vigour. The collection of supplemental data to evaluate rates of forest ingrowth, nutritional status of cattle and elk, and the impact of homesteader elk on hay production was also suggested.

Following completion of the problem analysis, a study was initiated to develop a word model relating carbohydrate cycling in bluebunch wheat grass and rough fescue, to both the effects of grazing and environmental factors. Completion of this report will delineate and rank specific hypotheses that require testing through field research in the East Kootenays.

EVALUATION OF QUANTITATIVE SAMPLING METHODS FOR DETERMINING THE IMPORTANCE OF CRYPTOGAMS AS INDICATORS OF RANGE SITE POTENTIAL AND CONDITION ON B.C. GRASSLANDS (E.P. 955) T. MCINTOSH

Relevant literature was reviewed and interviews conducted with range managers, plant ecologists, botanists, and biometricians to evaluate the importance of cryptogams as indicators for biogeoclimatic classification and their potential for determining range condition classes. The investigation assessed the availability and adequacy of existing sampling methods for cryptogams and the final report will recommend whether present methodology can be implemented in B.C. or new techniques require development.

HANDBOOK ON RANGELAND VEGETATION IN BRITISH COLUMBIA E. SMITH

This report identifies the needs and requirements for a range plant reference book for B.C. Specific recommendations regarding plant species are to be included, as well as text information for each taxa; considerations for printing, publishing, and artwork; costs; and personnel requirements for assembling such a publication.

A LITERATURE REVIEW OF FORAGE PRODUCTION AND LIVESTOCK GRAZING ON FORESTED RANGELANDS IN BRITISH COLUMBIA: ECOLOGICAL AND MANAGEMENT CONSIDERATIONS

L. NORDSTROM

The initial draft of the literature review has been completed and results from scientific literature on many aspects of grass/tree/cattle interactions on forested and clearcut sites have been summarized. Specific topics addressed in the review include: grass/tree competition; scarification requirements for seeding domestic forages; factors affecting germination and/or establishment of domestic forages species; timing of seeding grass in relation to replanting trees; and animal impacts on both seeded forages and coniferous trees. Based upon the literature reviewed, recommendations are provided regarding the need for such research in B.C.

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ACTIVE EXPERIMENTAL PROJECTS

E.P. 793	Ecosystems of the coast-interior ecotone in southwestern British Columbia	K. Klinka
E.P. 822	Ecosystem classification program for the Ministry of Forests	J.D. Lousier D.V. Meidinger
E.P. 822.01	Ecosystem classification in the Vancouver Forest Region	F. Nuszdorfer K. Klinka B. Green
	Plant indicator species for southwestern British Columbia	K. Klinka
	Guide for tree species selection and site preparation. Third Approximation.	K. Klinka F.C. Nuszdorfer

E.P. 822.02	Ecosystem classification in the Nelson Forest Region	G. Still M.V. Ketcheson
E.P. 822.03	Ecosystem classification in the Kamloops Forest Region	W.R. Mitchell
	Foliar analysis - soil analysis correlation	B.G. Bancroft
E.P. 822.04	Ecosystem classification in the Cariboo Forest Region	W.J. Watt
E.P. 822.05	Ecosystem classification in the Prince Rupert Forest Region	J.J. Pojar
E.P. 822.06	Ecosystem classification in the Prince George Forest Region	A. McLeod
E.P. 868	Ecological investigations of wildfires in northern B.C.	D.V. Meidinger J.J. Pojar R.L. Trowbridge
E.P. 887	A biological study of the dry south-central region of B.C.	T.T. McIntosh
E.P. 903	Habitat relationships of mule-deer in the Interior Douglas-fir Zone of central British Columbia	H.M. Armleder
E.P. 905	The simulation of Landsat-D and an assessment of its capabilities for the inventory and assessment of wetlands for management purposes	G.F. Tomlins
E.P. 912	Roosevelt elk/intensive forestry interactions	D.W. Janz
E.P. 916	Effects of intensive forest management on non-ungulate wildlife	K. Sadoway
E.P. 920	Investigations of soil temperature in ecosystems of the Prince Rupert Forest Region	R.L. Trowbridge K. McKeown
E.P. 923	Black-tailed deer in Second Growth Forests on Vancouver Island	R. Davies

E.P. 930	An ecosystematic approach to silvicultural management of immature forests - Sayward Forest Study .01 Ecosystems of the Sayward forest - their description and interpretation. .02 Stand mapping in second growth forests for intensive forestry planning. .03 Forest humus forms in the Sayward forest in relation to productivity and ecosystematic classification.	K. Klinka R.N. Green J.B. Nyberg
E.P. 931	A problem analysis of grassland classification	A. Nicholson
E.P. 934	Intensive forestry effects on Vancouver Island deer and elk habitats	J.B. Nyberg
E.P. 936	Problem analysis: Interactions among forestry, range and wildlife management in the East Kootenays	M.D. Pitt
E.P. 939	Caribou-forestry interactions in B.C.	D.F. Hatler S.K. Stevenson
E.P. 942	Ecosystem association mapping in the Truax Basin of the Kamloops Forest Region	W.R. Mitchell R.D. Winkler
E.P. 943	Soil moisture and temperature investigations in the Kamloops Forest Region	R.D. Winkler
E.P. 947	Investigations of atmospheric and soil climate in the Dome Creek - McBride - Valemount area of the Rocky Mountain Trench	W. Blashill G.D. Hope A.J. McLeod
E.P. 950	An evaluation of sampling and analysis systems for wildlife habitat analysis	R. Page
E.P. 951	Wildlife habitat handbooks for the forests and rangelands of B.C. and associated projects	R. Ellis
E.P. 952	Coastal grizzly bear - forest harvesting interactions	R. Archibald (F&W)
E.P. 953	Operational broadcast burning - site productivity trials	A.M. Macadam

E.P. 955	Evaluation of quantitative sampling methods for determining the importance of cryptogams as indicators of range site potential and condition of B.C. grasslands	T. McIntosh
E.P. 957	Foliar analysis studies in the Prince Rupert Forest Region	R. Trowbridge D. Yole
E.P. 963	Quantification of soil nutrient regime	G.D. Hope A.J. McLeod
E.P. 966	Post-planting spruce ecophysiology	D. Draper J.D. Lousier D. Spittlehouse W. Binder R. McMinn

BIOMETRICS AND RESEARCH-SYSTEMS SECTION

M. Kovats, Manager

The Biometrics and Research-Systems Section provides statistical, mathematical, and analytical consulting services, conducts research in biometry, growth and yield simulation, and quantitative and population genetics. In addition, the Section provides systems design, maintenance, data storage and protection facilities, and analytical and computing assistance to all headquarter and regional research staff.

The growth and yield research is reported under Silviculture Research (p.) and achievements in quantitative and population genetics can be found under the Tree Improvement Section (p.).

Except for specifically numbered experimental projects (E.P.'s), activities reported in this summary are selected topics of major involvement by our staff, or alternatively, a generalized statement of the type of work carried out during the past year.

APPLICATION OF LINEAR PROGRAMMING (LP) TO SEED ORCHARD AND NURSERY STOCK PRODUCTION SYSTEMS (E.P. 965) D. ERRICO

A model describing the operation flow for all species combined has been formulated and run. Opportunities for costs savings through alternate cultural techniques have been identified, as well as indications on which facilities (such as transplant space, container holding area, etc.) are most valuable. A presentation of results was made to the Manager, CLRS, Directors of Research and Silviculture Branches, and to a Workshop for disease, insect, and cultural treatment of propagation stock held at Cowichan Lake Research Station in February 1983.

A new project for formulating a linear programming model for interior spruce nursery production has been outlined, a schedule prepared and flow diagram drawn. A presentation has been made to the Directors of Research and Silviculture Branches to outline the project.

WILDLIFE HABITAT USE-AVAILABILITY SAMPLING DESIGN AND ANALYSIS H. STAUFFER AND V. FLETCHER

Methodology and computer software has been developed to analyse radio telemetry data for wildlife.

The sampling design and analysis of pellet group data for determining estimates of wildlife intensity was addressed in a Pellet Group Workshop on 7 December, 1982, and advice was given on the following projects:

a) E.P. 930.01. Ecosystems of the Sayward Forest: Their description and interpretation.

b) E.P. 903. Habitat relationships of mule deer in the Interior Douglas-fir Zone of central B.C.

APPLIED BIOMETRICS AND ANALYTICAL SERVICES W. BERGERUD

Some indication of the type and amount of work conducted during the past year is reflected by the following approximate statistics:

No. of statistical analyses performed:	55
No. of projects reviewed:	25
No. of consultations given (statistics):	55
No. of consultations given (stat. computing):	31
No. of workshops conducted (statistics):	3
No. of workshops conducted (stat. computing):	8

Strong effort has been extended to provide help to regional researchers in experimental, analytical, and computational techniques. The response to these efforts was appreciative and positive. It is intended to place a continuous emphasis on training in statistical computing and on assisting researchers in keeping up with changes in technology in this rapidly developing field.

Contact has been made with Ministry staff to identify typical problems and procedures where the application of statistical techniques may provide better, more reliable approaches than currently used methods. In an attempt to resolve some of these problems, methods for exploratory analysis, unbalanced data analysis, and the analysis of categorical data have been investigated and tested. Two informal notes have been written describing the analytical techniques related to these techniques.

RESEARCH SYSTEMS AND COMPUTING SERVICES R. ROBERGE AND E. BUCHMUELLER

Keeping in line with the current trend for developing "user-friendly" systems, most of the frequently used programs were incorporated into "menu-driven" procedures to assist researchers in processing their data. These "menus" display the various options available to the researcher and provide an easy-to-use tool for accomplishing the required computing tasks (e.g. determination of home range, location of radio collared animals, and centers of distribution).

Computing expenses were reduced several-fold for the Ecology and Earth Sciences Section by an efficient computer program which produces vegetation and environmental-mensuration information in a special format.

Some of the technical problems in transferring automatic weather-recorder data were resolved by using the capabilities of the word processing equipment located at headquarters.

GROWTH AND YIELD SAMPLING AND EXPERIMENTAL DESIGN REVIEW H. STAUFFER AND V. FLETCHER

Present plot designs required for growth and yield research are extremely costly. This high cost severely limits progress in this area. In the present economic climate, an alternative, more economical design seems the only feasible option.

A thorough review is being conducted of current growth and yield sampling and experimental design methodology to determine the "best" design possible under current cost constraints. The study consists of:

1. a thorough literature review;
2. on-going discussions with growth and yield specialists;
3. an examination of the role of tree growth simulators in growth and yield research design and analysis;
4. use of CFS Shawnigan Lake data for comparing sampling designs, possibly through the use of computer simulation; and
5. use of Ministry growth and yield data and analysis results for further examination of contrasting sampling designs.

A report outlining the findings of this review and making recommendations for experimental design will be issued at the completion of this project.

APPLICATIONS OF QUANTITATIVE METHODS IN FOREST PROTECTION H. STAUFFER

Lightning Location System

(a) Error Analysis:

Detection devices have been installed throughout the province to record the locations of lightning strikes. Due to geographic conditions, magnetic effects, and wave propagation phenomena, significant errors have been occurring in the bearings of these sitings. Error ranges are being examined for the bearings around each direction finder and reduced by using data collected from several direction finders which have been simultaneously recorded for the same lightning strikes. In this way, reduced error ranges are being established and distance independent assumptions about the errors are being examined.

(b) Improved Triangulation:

Lightning locations are currently estimated by taking the intersection of the sitings of the two strongest direction finder signals. Improved methods are being developed by using intersection polygons generated by error range sections for sitings from each direction finder.

OPERATIONAL RESEARCH IN THE MINISTRY OF FORESTS

Silviculture Branch
Seed Production Section

NITROGEN FERTILIZATION OF DOUGLAS-FIR SEED ORCHARDS (Vancouver Island) (SX 82601)

Three forms of nitrogen fertilizers were applied in 1981 and 1982 to 20 trees each in four Ministry of Forests coastal seed orchards to assess cone induction responses.

Calcium nitrate [$Ca(NO_3)_2$], ammonium nitrate [NH_4NO_3], and sulphur coated urea [$CO(NH_2)_2$], were hand applied under the driplines of 10- to 20-year-old trees at a rate of 400 kg N/ha. All were applied at the time of vegetative bud burst.

The effect of fertilizers applied in spring 1981 will be assessed in 1983 after cones produced in 1982 are processed and seeds tested. Results from 1983 fertilization will similarly not be available until early 1984.

Results to date indicate that the nitrogen fertilizers supplied at the above rates induced at least a two-fold increase in cones over controls, that ammonium nitrate was the most cost-effective cone inducing fertilizer, and that sulphur-coated urea appears to produce the heaviest seed crop.

ROOTPRUNING (Vibratory Plow) TRIAL (SX 82604)

Root pruning in coastal seed orchards has been studied since 1974 (Forest Research Review 1975/76), and it is now considered an operational cone induction treatment that is used primarily in the maritime climatics zone (Campbell River) where limited drought stress occurs. Use of the 44 inch Vermeer Tree Spade for rootpruning has become impractical because of the large size of the trees.

Thus, in 1982 this study was initiated to assess the cone production response and biological effect of rootpruning using a vibratory plow. Rootpruning with the vibratory plow was carried out in March 1982. Two distances from candidate trees boles were plowed, 1.5 and 2.0 m. Rootpruning was conducted on three sides or four sides of the randomly selected trees.

Results will not be available until late 1983 after cones initiated in 1982 are collected and seeds extracted. After machine modifications, the trial will be repeated in 1983.

COMPARISON TESTS BETWEEN A HARDI MISTBLOWER AND HYDRAULIC SPRAYER FOR INSECT CONTROL IN COASTAL SEED ORCHARDS (SX 82605)

In the past, insect control spraying has been carried out in Ministry of Forests coastal seed orchards using a hydraulic Technoma sprayer mounted on a "Girette" manlift. In 1980 a Hardi mistblower was purchased to provide an alternative spraying technique.

Testing was carried out in 1982 to compare the operational speed and effectiveness of the two spraying systems. The biological effectiveness of each spray technique in controlling cone and seed insects could not, however, be assessed, as the 1982 insect infestation levels in coastal seed orchards were too low to justify spraying.

Observations from 1982 concerning equipment speed and mechanical effectiveness indicate that the mistblower treats trees significantly faster than the hydraulic sprayer and provides a more complete spray coverage. No significant difference in the amount of spray used was found.

An important consideration when using chemicals such as Dimethoate (LD-50 oral 215 mg/kg dermal 400 mg/kg) is the amount of spray drift and consequently the hazard to spray applicators.

This study found that spray drift was not significant using the hydraulic sprayer but was considerable when using the Hardi mistblower even under very light wind conditions. It is essential when using dimethoate in spray equipment of any kind that protective clothing and a respirator be worn.

SUPPLEMENTAL POLLINATION OF DOUGLAS-FIR (SX 82606)

Supplemental pollination is commonly used in coastal Douglas-fir seed orchards as a method of ensuring that adequate quantities of pollen from "superior" trees are introduced to receptive female flowers within the orchards that lack sufficient orchard pollen. Over the past five years the Silviculture Branch has developed compressed-air fed pollen applicators or "wands" to apply pollen supplementally to seed orchard trees. With the purchase of a Hardi mistblower in 1981, it was felt that this unit might have a use as a pollen applicator.

In April 1982, a trial was conducted to compare the effectiveness of the hand wand and the Hardi mistblower as applicators in terms of filled seeds per cones produced. No significant difference was found in seed set between the two methods. Using different nozzle sizes, air blast pressures and distances from trees, this trial will be repeated in 1983.

POLLEN BANK EXTRACTION TESTING (SX 82607)

Large quantities of pollen from Douglas-fir orchards and clone banks are processed annually. This pollen is used to supplementally pollinate seed orchards trees, both in young orchards where natural within-orchard pollen supplies are low, and in older orchards where an increased yield and improved genetic quality of seed is desired.

Several questions concerning the design of operational pollen extraction systems need to be answered. For example, data is required to determine expected pollen bud drying times; desired extraction air temperature, relative humidities, and volumes; and yield of pollen per unit of buds collected and cost per unit of pollen collected. Using the Koksilah Pollen Bank facilities at Duncan, some of these questions were investigated in 1982.

Pollen buds were dried in three types of extraction units: the coastal seed orchard 2-tray extraction unit holding 4 litres of buds; the coastal seed orchard 6-tray extraction unit holding 12 litres of buds; and a prototype 6-tray extraction unit designed by central interior seed orchard staff.

Extraction air temperatures and humidity levels were taken continuously throughout the bud drying cycle. Bud moisture contents were determined before drying began and every 4 hours thereafter until completely dry to the touch.

Using the coastal seed orchard 2-tray system, an average extraction in temperature of 31°C, 3% relative humidity, and air flow volume of 600 feet per minute, buds could be completely dried in an average of 26 hours. Drying times varied considerably, depending on the intitial moisture contents of the buds. More surprisingly, yield of pollen extracted also varied with initial bud moisture content.

The coastal seed orchard 6-tray pollen extraction unit dried pollen buds in less than 36 hours on average, yet yielded, because of its increased capacity, two times as much pollen as a 2-tray unit did over the same time period.

This work will continue in 1983. The study will be done using engineering inputs from Technical Services Branch staff. The eventual aim of this work is to design an efficient bulk Douglas-fir pollen extractory unit and to provide documented operational instruction procedures which can then be made available for use by other seed orchard facilities.

CONE AND SEED LOSSES STUDY (SX 82609Q)

For various reasons, yields from seed orchards have not yet reached anticipated levels. Several explanations have been offered for the reduced yields, including low seed set, severe insect damage, premature cone collection, incomplete extraction, and inaccurate cone volume measurements. Upon recommendation of the Coastal Tree Improvement Council, an Orchard Cone and Seed Sampling Subcommittee was asked to study the problem and develop standardized sampling procedures to evaluate losses due to abortion, insects, and other causes.

The result was a detailed working plan co-ordinating the efforts of Silviculture Branch and Research Branch staff of the B.C. Ministry of Forests and Canadian Forestry Service, four coastal seed orchards, and the Duncan Seed Centre. All aspects of seed orchard production will be monitored so that cone, seed, extraction, and germination efficiencies can be calculated.

Figure 11. Extraction at the Ministry Seed Centre is being monitored as part of a study of seed orchard production efficiency.

HERBICIDE TREATMENTS AT RED ROCK (SX 81511Q)

In 1981, trials were initiated to find a herbicide to control Indian Paint Brush, a herbaceous alternate host for stalactiform blister rust of pine, around the Red Rock Seed Orchards. Ultra-low-volume (ULV) Roundup applications made in July 1981, as well as back pack applications of 2, 4-D, MCPA, Micoprop, Roundup or a combination of 2, 4-D, Micoprop and Dicamba made in May 1982, all significantly reduced Indian Paint Brush populations. Spring treatments in 1982 gave better control. It is possible to reduce Indian Paint Brush populations and therefore the amount of rust inoculum around seed orchards using any of these herbicides at label rates for broadleaved weed control. 2, 4-D appears to be the best choice based on the degree of control (98-100% reduction) and the cost involved (approximately $7.09/ha).

CONE AND SEED INSECT CONTROL TRIALS (SX 82301Q)

Tests of tree injections and soil applications of systemic insecticides against Douglas-fir cone and seed insects began in 1982. Low insect populations at all sites prevented the collection of efficacy data. Treatment costs were calculated at $10.56-$13.84 per tree for injections and $3.45-$6.00 per tree for soil treatments. These costs may be warranted to protect high value seed or where environmental effects of spray drift must be avoided. Further trials are planned on Douglas-fir as well as spruce.

SPRUCE GALL APHID ASSESSMENT (SX 82610Q)

Spruce gall aphid is a pest of spruce which has the potential to reduce cone production. This trial was initiated to monitor populations of this aphid at the Skimikin Seed Orchards, to assess the damage potential, and to evaluate control measures. Data will be collected over a number of years.

QUANTIFICATION OF SEED LOSSES IN DOUGLAS-FIR SEED ORCHARDS (SX 82609Q)

In 1982 four Ministry of Forests coastal Douglas-fir orchards were monitored to quantify seed losses due to:

1. flower and cone abortion,
2. seed set below an operational target,
3. extraction and processing, and
4. seeds not germinating.

The initial results indicate that no signficant sources of seed loss were encountered in 1982. On average, 80% of female flowers developed into mature cones. Seed set in each orchard approached or exceeded the operational target. Extraction, processing, and germination losses were minimal.

The objective of this trial, initiated by Silviculture Branch, is to develop efficient sampling procedures to monitor seed losses in orchards and throughout the various cone and seed processing operations. Research support in this joint trial is being provided by Research Branch and the Canadian Forestry Service. The trial will be continued over several years to enable quantifying year to year variation of seed losses. A progress report describing 1982 results is under preparation.

WEED CONTROL IN A YOUNG INTERIOR SPRUCE SEED ORCHARD (SX 81601K)

This trial evaluated six weed control treatments (black plastic, white plastic, simazine 2.2 kg a.i./ha, sawdust, glyphosate 1.2 kg a.i./ha, wood chips) in an interior spruce seed orchard. The study found that black plastic provided significant control against weeds but was expensive, and that simazine was the most effective and economical weed control treatment.

PUBLICATIONS

Albricht, M. and P. Birzins. 1982. Relationship between filled seeds per halfcut and filled seeds per cone in interior spruce. Tree Planter's Notes 30:35.

Birzins, P. 1983. Evaluation of six weed control treatments in an interior spruce seed orchard. Tree Planter's Notes 34:10-12.

Nursery Development Trials

ROOTSTOCK PRODUCTION TRIAL - USING PSB 415B's AND 615's (SX 82201Q)

This trial is designed to determine if suitable rootstock can be produced in one year to enable grafting of Fi, Si, and Pl scions at the start of the second year. This would have the benefit of taking one year off the current rotation for seed orchard stock.

The first year results indicate sowing early in PSB 415B's and 615's and transplanting into square pots in August-September was very successful. Although heights were lower (25-35 cm) than desirable, root diameters were exceptional (5-8 mm). Grafting of scions was completed in March. Initial results will be available later this year.

GROWING LARGE STOCK IN ONE- AND TWO-YEAR ROTATIONS (SX 82202Q)

This is an assessment on the production of large container grown Si and Ss at Thornhill using different sowing dates, facility combinations, and culture programs. One of the main purposes of this trial is to explore low energy rotations, that is, production in an unheated shelterhouse and outside (two-year rotation), versus the high energy demands of a heated greenhouse (one-year rotation).

Only the one-year portion of the trial has been assessed. The results indicate that very good quality seedlings can be produced in a heated greenhouse with early sowing - no later than 15 February for PSB 615's. Ss seedlots ranged 40-50 cm in height with a root collar of 5-7 mm while Si seedlots were 30-40 cm in height and 5-7 mm at the root collar. In many seedlots, especially Ss, it was apparent that outside conditioning and stressing to control heights were essential to produce quality seedlings.

Assessment on the two-year stock will be done later this year when those seedlings reach target specifications. An early inspection for winter damage indicates minimal losses in overwintered stock.

PELLETED SEED TRIAL USING Cwr (SX 82203Q) See E.P. 909.05 C. Leadem

The purpose of this trial was to determine if pelleting seeds of Cwr would have any negative effects on germination rate, stock quality, and size. This trial was a prelude to a mechanized sowing of cedar, previously done by hand.

Treatments were set up to compare pelleted seed from Moran Seed Inc. with unpelleted controls. A water spray treatment was also added to test for seed coat breakdown.

The results indicated no significant differences in germination between treatments at $p = 0.05$, although overall germination was suppressed compared to the lab. Neither were there any notable losses in stock quality.

However, a supplementary monitor of the same seedlots in the production sowing indicated virtually no difference between pelleted - non-pelleted seeds and the lab germination. This has been attributed to a very light grit cover (L 3 mm) used in production sowing which was considerably less than the 12 mm ± used for the trial.

ROOTSTOCK ASSESSMENT OF MODIFIED SQUARE POTS (SX 82204Q)

The BCFS square propagation pot, developed in 1981, was modified to permit increased stocking capabilities and better root direction along the bottom mesh. This trial is an assessment of the modified pot using rootstock from surplus Pl and Si from Thornhill Nursery. Other treatments compared different soil mixes and the use of cupric carbonate in latex paint on sidewalls and bottom. The stock has shown excellent growth during the past year and will be assessed for root form in late spring.

CHEMICAL ROOT PRUNING OPERATIONAL TRIAL (SX 82205Q)

This trial was designed to determine the causes of the variability of the chemical root pruning treatment in SX 81212Q. The factors examined were seedlot effect, nursery effect, soil mix, and facility (sheltered environment versus outside growing).

There were two nurseries chosen, Skimikin in the Kamloops Forest Region and Harrop in the Nelson Forest Region. The results at Harrop were entirely satisfactory in all treatments of the three Pl seedlots grown. Virtually all primary lateral roots in the upper plug were pruned and there was no apparent growth reduction due to the treatment. The chemical root pruning treatment at Skimikin Nursery proved entirely unsatisfactory. The treatment reduced growth (and produced severe iron chlorosis) and virtually no first-order lateral roots were pruned.

Nigel Burdett is currently examining cultural effects which may have caused the variation in treatment experienced in SX 82205Q and SX 81212Q (E.P. 790.07 Cultural Factors and Chemical Root Pruning in Container-Grown Lodgepole Pine).

The planting section of Silviculture Branch will establish a field outplanting trial (SX 82205Q) to compare the survival and performance of treated and untreated stock of seedlots 2625 and 4277 which were grown successfully at Harrop Nursery last year.

ASSESSMENT OF PROPRIETARY FERTILIZERS FOR CONTAINER CROPS (SX 82206Q)

Soluble fertilzers manufactured by Peters Fertilizers and Plant Products were compared to standard Green Valley regimes in growth results for container spruce and pine seedlings. Conventional products and specialized forestry formulations developed by Peters were included. Formulations were compared at 100 and 200 ppm N. The trial was split, one half receiving additional ferrous sulphate applications every second week. Osmocote regimes were included.

Ferrous sulphate, normally included in fertilizer regimes to prevent chlorosis, resulted in large increases in height growth in conjunction with Green Valley and Plant Prod fertilizers, but not with Peters Forestry or Osmocote regimes. Ferrous sulphate applications did not improve root weights. Also, there was no advantage to utilizing soluble fertilizers at 200 ppm N compared to 100 ppm N.

Dry weight results indicate that both Peters and Plant Products conventional fertilizers compared favourably to the standard Green Valley regime, as did the Peters Forestry formulations. Osmocote 18-6-12 (9-month) produced the highest root dry weights in spruce. Statistical analysis of results is being conducted by the Research Branch.

COMPARISON OF PEAT SOURCES AND GROWING MEDIA (SX 72207Q)

Growth of container spruce and pine seedlings in standard peat-vermiculite using Fisons-Western peat from Delta was compared to growth using other peat sources. These included Fisons-Western peat from Manitoba, Black Diamond peat from Grindrod, B.C., and Langley Peat North from Alberta. Commercially available growing media from Fisons-Western and W.R. Grace were also compared.

General observations noted better colour in the Alberta and Manitoba peat sources. There was also better colour in Ministry growing media compared to commercially available media. Black Diamond peat contained many weeds and will not be considered in future.

Dry weight results indicate that Alberta and Manitoba peat produced growth comparable to the standard peat from Delta. Since the Delta peat is no longer being baled, the other two sources would be acceptable substitutes. The commercially available growing media tested performed reasonably well, and should be considered in nurseries not wishing to purchase soil mixing equipment.

MICRO CONTAINER TRANSPLANTS (SX 82208Q)

Sitka spruce, interior spruce and western hemlock seeds were sown in the smallest Speedling trays, to be transplanted to 415A's and 615's after two months' initial growth. Speedling trays were greenhouse grown and after two months, transplants were moved outside to shadeframe and open areas.

Sowing dates in the latter part of March and low light levels produced small initial growth. When transplanted and moved outside, subsequent growth was very slow. As a result, all transplants were smaller than PSB 211 controls and much smaller than anticipated. Dry weights and other measurements were not taken.

LIME AMENDMENT TRIAL (SX 82209Q)

A new source of dolomite lime, Greenleaf, was compared to standard Green Valley 12 mesh and finer at 1, 3 and 5 kg/m^3, in the growth of container Douglas-fir and pine seedlings. Some treatments recieved additional ferrous sulphate, manganese sulphate, or both.

Applications of ferrous sulphate or managanese sulphate increased colour of seedlings, and the darkest colour was achieved when both were applied in addition to standard Green Valley soluble fertilizer regimes. Ferrous sulphate or both ferrous and manganese sulphates resulted in large increases in seedling heights and top weights, but root weights were not increased proportionately.

There was no consistent effect on root weights from using 1, 3, or 5 kg of either lime source. In coastal nurseries, Greenleaf lime at 3 kg/m^3 or less could be substituted for Green Valley. In nurseries having water containing considerable amounts of calcium and magnesium the finer Greenleaf lime should be introduced cautiously to avoid iron chlorosis problems.

OSMOCOTE - NUTRICOTE TRIAL (SX 82210Q)

A new controlled release fertilizer, Nutricote, is being marketed in competition to Osmocote. A 4-month formulation of Nutricote was compared in growth response of spruce and pine to a 4-month formulation of Osmocote. A new 9-month Osmocote (13-13-13) was compared to standard 9-month Osmocote (18-6-12).

Dry weights of seedlings indicate that Nutricote will be an acceptable substitute for Osmocote. Under outdoor growing conditions, the Nutricote apparently lasted longer than 4 months. Many time release spans are available in Nutricote and further testing will be required. The new Osmocote formulation 13-13-13 did not last for the growing season and would not be considered as a replacement for Osmocote 18-6-12.

FALL SOWING TRIAL (SX 82211LQ)

Styroblocks were sown with interior spruce and western hemlock on 23 August, 1982 at Green Timbers nursery. After a short initial growth period these blocks were overwintered in a cold greenhouse.

In early March, the hemlock was moved into a greenhouse holding the 1983 fall planting hemlock crop. The trial blocks have flushed and are considerably ahead of the normal spring sown crop. The concept is that crops of very good quality for fall planting could be produced on an August-to-August crop cycle, rather than being sown in early spring.

The spruce blocks were moved outside at the end of February and commenced to flush erratically without the aid of photoperiod lights. This cropping schedule is part of a rotation that would produce spruce crops for summer planting in the Prince George Forest Region. Observations will determine if the sowing date was appropriate to produce quality stock for an August planting date.

Planting

PLUG TRANSPLANT TRIAL (SX 81104Q)

The object is to compare the survival and growth of interior spruce PSB 211-transplants to that of PSB 313, 2+0 bareroot and 2+1 bareroot stock types, planted on a brush prone site in the Prince George East Forest District.

After two growing seasons the survival rates of the PSB 313, 2+1 BR, and PBR were very high - over 85%. The survival rate of the 2+0 BR was 62%. In terms of total height, and height increment, the PSB 313 was clearly the best performer, followed by the 2+1 BR. Growth of the 2+0 BR and PBR was relatively low.

The performance of the plug-transplant was disappointing, failing to demonstrate rapid initial growth.

Seeding

SPOT SEEDING COVERS (SX 82303Q)

The objective of this trial is to determine:

1. the comparative germination and initial growth of lodgepole pine when unstratified seed is sown and covered with plastic cones of various types.
2. the extent of biodegradation of the various cones after two growing seasons.

The trial was established on a cutover site near Angus Creek (Cranbrook Forest District) in spring 1982. Plastic covers being tested are the Finnish Sheltercone, the Cerbo Sheltercone, and the Cerbo Sheltercone Inverted, which is put into the soil with a plastic cap placed above. Uncovered spots were seeded as control. Two lines of 25 spots of each treatment were randomized on both favourable and unfavourable aspects. Seven seeds were placed on each spot. The trial was examined in fall 1982 (see Table 7).

BRACKE SEEDING (SX 81308Q)

The areas seeded in fall 1981 and spring 1982 were both visited in September 1982. Heavy use by cattle during summer resulted in damage to most of the seeded spots from trampling and depositing of "pies". No Pl germinants were observed in the Bracke-prepared spots.

It is apparent that seeding of unstratified Pl, even on prepared spots, should not be undertaken where heavy grass or weed cover is present, or where soils are silty or clayey and tend to retain moisture. A complete examination of this trial will be undertaken in summer 1983.

Table 7. Results of a fall 1982 examination of a field trial testing three spot seeding covers (SX 82303Q)

		Covered Spots			
		Cover Missing		Cover in Place	
Treatment	Aspect	No.	Number of* Germinants	No.	Number of* Germinants
Finnish Sheltercone	Favourable	-	-	50	3
	Unfavourable	-	-	50	-
Cerbo Sheltercone	Favourable	6	-	44	5
	Unfavourable	3	-	47	-
Inverted Cerbo Cone w/cap	Favourable	4	-	46	10
	Unfavourable	4	-	46	9
Uncovered Spots	Favourable	3 Germinants			
	Unfavourable	0 Germinants			

*Total of 50 spots, 7 seeds placed at each spot.

Stand Tending

MSMA INJECTION TRIAL (SX 79602Q); GLYPHOSATE INJECTION TRIAL (SX 80400Q)

These trials were established near Cranbrook, B.C. to determine the lowest rates of MSMA and Glyphosate needed to kill lodgepole pine in the 10 cm dbh class. Treatments were carried out in the spring and fall using six different injection rates.

Fall injections of MSMA reached a 90% mortality level in pine within 22 months after treatment at rates as low as 2.0-2.5 ml/stem. Spring MSMA injections do not cause tree death with the same rapidity as fall treatments. Only with injections totalling 5 ml or more per stem, does MSMA kill 90% of the treated stems. Spring injections of 5 ml or less have achieved a high of 74% in 27 months, whereas similar fall injections show 100% kill by the 22nd month.

Spring injections of Glyphosate reached the 90% mortality level 14 months after treatment at rates as low as 1.0 ml/stem. Fall Glyphosate injections show comparable mortality levels as the spring treatments but more time, 22.5 months following injection, is needed to match spring treatment results.

SALAL CONTROL TRIAL (SX 82506Q)

In May 1982, Silviculture Branch initiated this trial to determine the efficacy of Roundup, Tordon 22K, and Garlon (used at three rates) on salal.

Five months after treatment an occular assessment showed only minor damage to salal using high rates of Roundup and Garlon. Tordon 22K appeared to offer the best control, especially at the highest rate (1000 g a.i./ha). All herbicides showed good control on Salmonberry, Alder, and other herbaceous vegetation. A formal assessment will be carried out during the summer of 1983.

INVENTORY BRANCH

GROWTH AND YIELD STUDY IN MANAGED FOREST STANDS

Of the 85 forest-productivity installations (Research Branch, E.P. 703) established in coastal Douglas-fir and western hemlock, 24 installations consisting of 280 plots were remeasured by inventory crews during the fall of 1982. These research installations are designed to measure stand responses to combinations of juvenile spacing and fertilization treatments. Three- and six-year measurements from 70 mm large scale aerial photography were continued. Editing of all photo measurements and comparisons with the actual field measurements have been carried out for establishment, 3-year measurements, and some 6-year measurements.

Under the auspices of the Intensive Forestry Monitoring Program, 24 installations comprising 280 permanent sample plots were established in various stands throughout the province. Of these, 22 installations were operationally spaced in 1982, and two installations were operationally spaced and fertilized in 1982.

Sampled stands in the Cariboo Forest Region averaged 60 years of age, and 25 years of age in the other three regions where plots were established.

GROWTH AND YIELD STUDY IN NATURAL FOREST STANDS

In 1982, 173 permanent growth plots were remeasured in Forest Inventory Zones B (lower coast) and D (interior). In addition, 42 experimental samples were remeasured in Forest Inventory Zone G (interior).

RELATIONSHIP OF STAND GROWTH AND YIELD AND ECOSYSTEM CLASSIFICATION UNITS

This project, initiated in 1981 for the ecological classification of permanent sample plots, was continued in 1982 in cooperation with the research section of the Vancouver Forest Region. A further 46 permanent sample plots in Douglas fir stands were classified into the ecological classification system. In addition, ecological classification was carried out at 35 locations, and historical growth rates for 140 Douglas-fir trees were also determined. Analysis of the data available to date indicates encouraging relationships between site index and volume-age relationships, and ecological classification.

VARIABLE DENSITY YIELD TABLES AND EQUATIONS

Variable density yield tables and equations for coastal Douglas-fir (Forest Inventory Zones A,B,C) were published in 1982 as Inventory Report No. 2. These equations estimate volume in cubic metres per hectare as a function of stand age, site index, basal area per hectare, and average diameter. There are also equations to estimate basal area per hectare as a function of age, and site index, and average stand diameter as a function of age, site index, and basal area per hectare. When stratification is done by means of aerial observation or air photo interpretation there are equations to estimate both basal area and average stand diameter as a function of age, site index, and crown closure.

ECOLOGY AND EARTH SCIENCES

OPERATIONAL RESEARCH - Research Extension

SLOPE STABILITY HAZARD MAPPING

A slope stability mapping workshop was sponsored by the Research Section of the Prince Rupert Forest Region. The workshop was a first step towards developing a uniform approach to slope stability hazard mapping for forest land planning. An open forum provided specialists with an opportunity to discuss mapping methods and philosophies. Working group topics examined: (i) mapping systems, (ii) interpretive classifications, (iii) hazard classification, (iv) regionalization, and (v) research needs. The workshop proceedings are unpublished, but available on request.

Operational application has shown that slope hazard classes are successfully delineated, at a map scale of 1:20 000, based on natural terrain features and on the active, or potentially active, status of the formative erosional processes in a land unit. Two hazard classification systems are evolving:

1. A three-class hazard system is mapped by establishing hazard ratings to units directly on air photographs. Approximately 75% of these units are then field inspected by helicopter. Experienced mappers are necessary to extrapolate stability information from detailed study areas of similar geology. Western Forest products (TFL 24) and Crown Zellerbach (TFL 2) have worked in a co-operative effort with the Forest Service to apply the three-class hazard system. Operative studies in addition to mapping of three classes has proven successful in assessing long-term management strategies and for identifying the landbase available for sustained timber production on these TFL's.

2. The five-class stability hazard system is also based on natural terrain features. But, the hazard map is derived more from a factor map in which some of the parameters important for assessing slope hazard are identified in a terrain polygon. The terrain polygons are delineated based on airphoto interpretation with a field inspection of 25 to 30 percent of the units. This five-class system is tailored for development planning of a watershed with more intensive field time spent in assessing moderately unstable terrain. Terrain maps and slope hazard maps have been completed for 20 percent of the land area in TFL 39 Bk 6 (MacMillan Bloedel) and for charter areas in Rennell Sound and Davidson Creek (CIPA) under Section 88(2) of the Forest Act.

PROTECTION BRANCH

FIRE STUDIES

A joint study with Silviculture Branch and the Canadian Forestry Service, involving the measurement of fuel loadings and characteristics for various tree species and spacing regimes, was completed. Data collected from coastal and interior locations were used to construct a computer model describing the fire behaviour potential of stand spacing projects. Guidelines for project design and execution relating to fire management considerations were issued.

With fieldwork and data analysis completed, reports on the ecology of fire in the Fort Nelson, Cassiar, and northern MacKenzie Timber Supply Areas are in the final processes of publication. The Canadian Forestry Service and Research Branch are co-operating in this study, the objectives being 1) to delineate the biogeoclimatic zones and subzones of the north, 2) to determine what the effects of forest fires have been in the forest types within these zones, and 3) to provide land managers with needed information and aids to assist in making multiple resource oriented land and fire management decisions.

The aforementioned co-operators, in conjunction with Planning Branch, have joined in a study to model the long-term impact of wildfire on the age class distribution of these northern forests, with special attention being given to future timber yields. The Fort Nelson Timber Supply Area has been selected to serve as a pilot project for the analysis.

Work has been initiated to develop values systems to answer needs in fire and pest management decision making. The objective is to produce computerized systems which will allow fire and pest managers to better define the effects of their efforts in terms of values lost or protected under various program levels, methods, strategies, and tactics. Such systems will also facilitate better communication between managers of resources, and those entrusted with their protection. Accomplishments to date include: evaluations of timber supply planning and allowable cut effect simulation models; Markov chain modelling of fire effects on timber supply; and a pilot project into the assessment of value loss due to Douglas-fir tussock moth infestations on private land in the Kamloops Forest Region. The work in B.C. will be carried out in conjunction with the Canadian Steering and Working Groups on Values Systems established by the Canadian Committee on Forest Fire Control.

EQUIPMENT DEVELOPMENT AND PRODUCTS TESTING

Using technology jointly developed by Lightning Location and Protection, Inc. of Tucson, Arizona and the Ministry of Forests, the lightning location network currently consists of 11 direction finder units in the central and southern Interior. Expansion of the network in 1983 to include four units in the north will give complete provincial coverage.

Computer graphic output terminals at regional offices permit users to access the data base held in the IBM computer in Victoria and thus to monitor lightning activity. Knowledge of lightning distribution has permitted more accurate routing and scheduling of patrol aircraft, and has influenced the deployment of forest fire suppression crews. Assistance with error analysis of the computer-derived lightning strike locations is being provided by the Biometrics Section of the Research Branch.

A 270 litre water container known as the Stilwell Tank was modified to fit under a Bell Jet Ranger helicopter. This rubber-canvas apparatus takes the place of a conventional 205 litre metal drum and is used to transport water for various fire suppression applications.

FOREST PEST STUDIES

Douglas-fir tussock moth infestations continued in 1982. Further trials were carried out to test the efficacy of varying dosage rates of the specific nuclear polyhedrosis virus (NPV) and of a variety of other insecticides. Indications are that reduced dosages of NPV are effective in causing an insect population collapse. Although infestations may be brought under control using this virus, there is little foliage protection in the year of application. Ground spray efficacy tests were also carried out using carbaryl, permethrin and *Bacillus thuringiensis* (Bt). Efficacy in terms of larval mortality in decreasing order of effectiveness was: permethrin, carbaryl, and Bt.

Dr. J. Borden (Simon Fraser University) conducted further mountain pine beetle pheromone research in the Prince Rupert, Kamloops and Nelson Forest Regions in co-operation with the Protection Branch and Regional staff. Chemicals were tested for attractiveness, and stands were intensively baited to prevent the spread of mountain pine beetle to other areas. Good beetle aggregation was obtained when trans-verbenol + exo-brevicomin + myrcene were used.

Dr. J. McLean and J. Churcher (University of British Columbia), in co-operation with Protection Branch and the Prince George Forest Region, carried out a study to judge the feasibility of using large scale aerial colour infrared photography for early detection of spruce beetle infested trees. Photographs were taken in July, approximately three months after insect attack. Although there were fewer infested trees in the photo plots than hoped for, it should be possible to classify various stages of attacked trees. A full report is expected in 1983.

ENGINEERING BRANCH

BIOMASS PROJECT

This is a joint federal-provincial study to evaluate the productivity and costs of harvesting and processing residual biomass on wet belt cedar-hemlock sites in B.C. A second objective is to establish the impact of the reduced costs of site rehabilitation and regeneration, as a result of harvesting biomass, on the net costs of that harvesting. The first phase of the study, harvesting of the biomass material, was undertaken in 1981. The second phase, processing and using studies, was completed during 1982. This project is one of several completed on the decadent cedar/hemlock problem during the past 15 years. It is anticipated that the results obtained will be used in further research to promote utilization of this material.

HAZARD RATING MAPPING SYSTEM FEASIBILITY STUDY

The purpose of this study is to determine the practicality of developing a computer system that would produce maps of site sensitivity to forest engineering operations. The study primarily consists of an investigation of data sources and their compatibility. If such a system is developed, it would assist in implementing the proposed Steep/Critical Slope Logging Guidelines and generally assist with the planning of harvest operations on a drainage basis.

STEEP/CRITICAL SLOPE LOGGING GUIDELINES

This project involves a study of problems associated with the development of certain stands of timber in the Interior, oresently classified as inaccessible because of geographical or environmental constraints. These problems will be equated to present and future logging systems to test the economic and practical application of these systems. Guidelines for steep-slope logging systems in the Interior will be recommended as a result of this work.

CHAIN LAND CLEARING

Land clearing by chain attached to two crawler tractors was used again last year for downing decadent cedar/hemlock trees, noncommercial forests, and stands destroyed by insects and disease or fire. This land clearing technique is a modified version of the "ball and chain" method, originally applied by Engineering Branch for reservoir clearing during the 1960's. The field tests at the Paul Fire site near Burns Lake indicated that the application of the chain for land clearing and partial silvicultural site preparation purposes is superior to other techniques currently in use. Silviculture Branch is planning further operational field trials in 1983. Engineering staff will be carrying out field surveys and time studies to fully evaluate the method.

CATERPILLAR D7G HYDRAULIC RIPPER SPOT SCARIFIER

The spot scarifier has great potential as a mechanized site preparation implement for wet forest soils representing good potential growing sites. The presence of large accumulations of slash and fast growing, competing vegetation inhibit tree planting and reduces seedling survival. A spot scarifier equipped with a specially designed V-blade can clear the slash and create a mound of inverted soil that can serve as a micro-site for future seedlings.

The D7G Caterpillar hydraulic ripper was considered best-suited to form the superstructure of the spot scarifier. The standard parallelogram ripper frame is used as a stress member of the implement, employing two shanks with up-and-down hydraulic cylinders attached. The action of the hydraulic cylinders allows the shanks to dig into the ground up to 60 cm. A hydraulic rotary actuator mounted on the tip of the shank can flip the soil around up to a maximum rotation of 150°. The hydraulic control system derives its power from the hydraulic pumps of the prime mover and consists of directional control valves (with manual override), hydraulic accumulators, speed control, and filter regulator assemblies. The electronic control system uses a controller capable of being programmed, and the input devices are of the discrete type with limit and proximative switches installed thoughout the system. The cycle time of the spot scarifier is regulated by the ground speed of the prime mover, and the control system is fully automatic, requiring little attention and corrective measures (through manual override) by the operator.

Initial tests were conducted in February 1983 to test the actions and check all controls while the machine was operating. The tests confirmed that the machine can function as planned, and with some design improvements and modifications it will meet silvicultural requirements. As soon as the modification work is completed the spot scarifier will undergo intensive operational trials in August and September 1983.

LICENSEE RESEARCH PROJECTS - SECTION 88(2)
VANCOUVER FOREST REGION

B.C. Forest Products Ltd.

AN ECOSYSTEM EVALUATION OF FORESTS ON THE WEST COAST OF VANCOUVER ISLAND WITH EMPHASIS ON THE WET SUBZONE OF THE COASTAL WESTERN HEMLOCK BIOGEOCLIMATIC ZONE (#22-09-01)

This is a co-operative study between the Ministry of Forests (Vancouver Forest Region) and British Columbia Forest Products Limited. Through the period 1978 to 1980, approximately 150 plots were established on the west coast of Vancouver Island. In each of these plots, environmental, soil, vegetative, and tree mensurational data were collected with the intent of differentiating and characterizing distinct ecological units within the Coastal Western Hemlock Biogeoclimatic Zone. Management interpretations for each ecological unit are being developed on the basis of these data. In addition, relationships between site productivity and selected soil parameters will be investigated.

All physical and chemical soil analyses have been completed and data processing and synthesis are continuing. Delays were encountered in the differentation and characterization of west coast ecosystems, but this work is scheduled for completion in 1983. Investigation of site productivity and soil relationships is on schedule and will be completed in the spring of 1983.

SOIL-SITE STUDY (#22-08-01)

The development of vegetational relationships for growth and yield plots on lands managed by British Columbia Forest Products Limited was initiated as a pilot study in 1977. Environmental data for the study were collected from previously established growth plots within Tree Farm Licence 22 located in the company's Port Renfrew and Caycuse Divisions.

The study involves a collection of detailed information on different forest sites to improve the data base from which forest management decisions are made. These data also serve as an instructional guide to field personnel, demonstrating the ecological significance and functional relationships between various environmental parameters and forest growth.

HYDROLOGIC RATE OF CUT ANALYSIS (#22-006)

The objective of this project is to develop a method for analysing the impacts of timber removal and subsequent forest regrowth on rain-on-snow generated peak flows.

The method which has been developed is computer-based, and accounts for the watershed characteristics and processes which translate point source rain-on-snow runoff to watershed peak flow. A computer program example, complete with a user guide, has been produced for a micro-computer. This program facilitates the evaluation of the effects of long-term forest harvesting plans on rain-on-snow peak flows in such a way as to permit the forest harvesting plan to be spatially and temporally modified to minimize adverse effects on peak flows. Because insufficient data are normally available for a rigourous rain-on-snow peak flow analysis, the methodology developed in this study is designed to be interactive so that user assumptions regarding rain-on-snow processes can be tested.

GROWTH MODELLING OF DOUGLAS-FIR (#22-008)

The objective of this project was to provide both immediate and long-term data for use in the calibration of the Research Branch TASS-Df growth model for stand density management regimes of interest to BCFP. Data collection concentrated on medium and low sites stocked at relatively low densities with predominantly Douglas-fir. The project was completed in early 1983 and involved the establishment of 24 permanent growth and yield plots within the Sixteen Creek plantation espacement study E.P. 534, and a further 10 plots within low density plantations in the Gordon River Block of TFL 22. All information was forwarded to Dr. K. Mitchell for incorporation with the TASS-Df data base.

Canadian Forest Products Ltd.

IDENTIFICATION OF ECOSYSTEM ASSOCIATIONS IN THE NIMPKISH VALLEY (#37-003)

The objective of this project was to identify local ecosystem associations in the CWHa subzone of TFL #37 using plant indicator species. Ninety ecological reconnaissance plots were established, and soil and vegetation data were collected on each plot. These plots were then analysed and sorted by computer into eight distinct ecosystem associations. These ecosystem associations were further grouped into seven silvicultural treatment units. These silvicultural treatment units will now form the basis for all future silvicultural prescriptions in the CWHa on TFL #37.

Crown Zellerbach Canada Ltd.

THE EFFECT OF THINNING AND FERTILIZATION ON THE GROWTH AND YIELD OF SECOND GROWTH STANDS (#2-002)

The objective is to evaluate the effect of thinning and nitrogen fertilization on the growth and yield of Douglas-fir and western hemlock second growth stands in TFL No. 2. The sixth-year remeasurement has been completed and an interim report is being prepared.

*THE ECONOMIC ANALYSIS OF DOUGLAS-FIR NITROGEN FERTILIZATION (#2-011)

The objectives of the study were to investigate the economics of fertilizing managed and unmanaged forests, and to develop a decision aid to assist in assigning priorities to candidate stands for fertilizer treatment. The final report was prepared, with consideration given to comments by Research Branch personnel, and submitted October 1982.

*ECOSYSTEM SURVEY OF TFL NO. 2, BLOCK 17, BONANZA LAKE - PHASE II (#2-016)

The objective is to develop a decision aid in map form for planning harvesting and silvicultural procedures, and to satisfy the land classification plan as required in TFL No. 2, Working Plan No. 6. The project was completed with the preparation of Phase II maps, a report, and a field guide. The mapping included identification of soils, terrain, and ecological data. The report and field guide provided data interpretations for engineering and forestry.

IMPACT OF DEER BROWSING ON YOUNG DOUGLAS-FIR PLANTATIONS AND ASSESSMENT OF METHODS TO REDUCE DAMAGE (#2-017)

The objectives are to determine the effect of animal damage on the survival and growth of recently established Douglas-fir plantations, and to determine the effectiveness of various types of animal damage protection systems. The project was established at Mayne Passage and Brougham Point on East Thurlow Island and will be assessed annually for four years.

MacMillan Bloedel Ltd.

TFL 20/21 LANDSLIDE STUDY (#616-3, 616-12)

The purpose of this study is to delineate the terrain factors most important for assessing hillslope stability, and to identify those terrain units which are typically most sensitive to logging. Field data collection has been initiated and should be completed early in 1983. Data analysis should be completed and a report presented by late 1983 or early 1984.

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*Projects funded in 1981/82

IMPACT OF PRESCRIBED BURNING ON FOREST PRODUCTIVITY (#123-1)

The overall objective of this project is to assess the effect of prescribed burning on the early productivity of Douglas-fir plantations on the east coast of Vancouver Island, in areas where salal is a major understory component. Field work was initiated in 1981 and completed in 1982. Foliar sampling took place in the fall of 1982. Foliar analysis and analysis of all data will be done early in 1983.

SECOND GROWTH - DEER WINTER RANGE STUDY (#616-17)

This project was implemented in 1981 in an attempt to determine if older second growth (60+ years) in Shawnigan Division, of suitable slope, aspect and elevation, can function as alternate winter range under heavy snow conditions. Study methods consisted of comparing deer utilization of selected older second growth with old-growth stands in winter, using track frequencies in snow as an index statistic. The study design also incorporated spring pellet group surveys on fall-cleared plots within study areas, to provide comparative habitat use data on a seasonal basis. The study is being carried out as part of the IWIFR Ungulate-Second Growth program. Essentially no winter data were collected in 1981 because of a lack of snow.

More severe snow conditions occurred in 1982. Results from track surveys strongly indicated that deer avoided older second growth compared with old growth under most snow conditions. Pellet group surveys supported this, although not at the level of statistical significance of $p=.05$. Snow accumulation data were inconclusive.

Study findings will be confirmed in 1983 by repeating the track and pellet group surveys if suitable snow conditions occur. If study conclusions from 1982 are supported, this suggests that 60-year-old second growth may be of limited use as deer winter range.

LEGUME-CONIFER-WILDLIFE INTERACTION STUDY (#555.7)

This study was designed to investigate the use of clover as a site preparation technique with respect to the following objectives:

1) To test on an operational scale whether planting freshly-burned cutovers with agronomic clovers will contribute to improved conifer seedling survival, establishment, and growth.
2) To test whether the operational use of legumes on areas subject to heavy browsing pressure by deer (e.g. on spring ranges near winter range) can substantially reduce damage to seedlings and plantations by providing preferred alternate forage.

Following a September burn on M-2000 in Shawnigan Division, ten 2-hectare plots were laid out and treated.

WESTERN REDCEDAR CONTAINER TRIAL (#312.4)

This project was initiated in 1980 to determine if existing container stock types of western redcedar could out-perform conventional 2+0 bare root stock. Three provenances were included to determine the influence of genetic variation in stock type performance. Each test location was as close as possible to one of the provenance locations.

The experiment has two parts, 1) to determine survival, and 2) to explain the height growth and survival differences based on changes in plant morphology (destructive sampling).

Findings to date include the following:

1. As in 1981, the third season survival was very good (97-100%) for all locations (Port McNeill, Sproat, and Kennedy) and stock types. No significant differences were noted among test locations, provenances, or stock types.

2. Survival over the three-year period was good for all stock types, with the exception of bareroot. Container survival ranged from 81-89%, bareroot survival was 68%. Much of this discrepancy may be explained by the root pruning of the bareroot stock prior to planting.

3. Height growth values were similar to the 1981 growing season, with height growth ranging from 8-28 cm. Height growth by stock type changed slightly from 1981. The bareroot (BR) stock type has come into its own and leads, followed by Ray Leach (RL) and Spencer-Lamaire (SL) types, and these were better than the Styro 211 and paper-pot (PP) types (BR less than RL, SL less than Styro, PP).

REGENERATION FAILURE ON SOUTH-FACING ASPECTS (#316.1)

This project was initiated to investigate factors influencing mortality of planting stock on high elevation sites on Vancouver Island. A secondary objective was to develop procedures to ameliorate these factors and improve survival and growth on these sites.

A steep, south-facing slope with a history of regeneration failure was chosen as a test site. Three species were planted (Douglas-fir, western hemlock, and Pacific silver fir) under shaded, inclined, and watered treatments. Seedling survival and growth were observed in conjunction with an array of environmental and physiological parameters. The primary objective here was to relate seedling performance and physiological responses to environmental conditions.

Preliminary analysis shows mortality was reduced through the use of shade cards, with differences existing between species. Watering did not significantly increase survival over shaded treatments.

OPERATIONAL BRUSH CONTROL TRIAL (#491.2)

This trial was established in Northwest Bay Division to compare mechanical versus chemical means of alder brush control on two problem sites. The objective was to demonstrate the efficiency of the treatments and to provide a base of local, quantitative data on treatment response and cost effectiveness under operational conditions.

In 1982, a pretreatment survey was carried out to assess brush competition and mechanical treatments were applied during the late summer-early fall period. The majority of the mechanical treatments had 2-10 cm of resprouting by December 1982.

A complete resprouting assessment of the mechanical treatments and the application of the chemical treatments will be carried out in 1983.

FIELD SURVEY OF LEGUMES IN COASTAL B.C. (#555.2)

The objectives of this field survey of legumes are to:

1. detail legume occurrence and distribution on lands of interest to MB in coastal B.C. (i.e. primarily those areas currently regenerating);

2. estimate abundance and biomass of legume populations;

3. evaluate stand types and environmental conditions, and correlate successful legume establishment with environmental factors;

4. estimate extent and amount of nitrogen-fixation in activity of legume species; and

5. select appropriate legume species for use in possible forest management programs.

Although no new plantations containing large amounts of naturalized legume species were identified this year, one legume species which had not previously been observed in Shawnigan Division is now appearing in abundance along roadsides and on cutbanks. This species is particularly invasive, and may now move into new plantations on its own. It is interesting to note that the plant is a naturalized cultivar of *Lotus corniculatus*, a legume which this research has been planting in other areas of the division for three years.

ISOLATION AND SELECTION OF *RHIZOBIUM* SPECIES (#555.3)

The objectives of this project are to:

1. isolate *Rhizobium* species from legumes found in areas of interest (i.e., primarily those areas currently regenerating) on MB lands;
2. evaluate the effectiveness of isolated *Rhizobium* strains of legumes of interest in greenhouse trials; and
3. select those *Rhizobium* strains that are best suited in terms of infectiveness (ability to form nodules) and effectiveness (efficient symbiotic relationship) for legumes growing in forest soils.

Under this project, bacteria were isolated which are more suited to acidic forest soil conditions than the agriculturally-oriented bacteria sold commercially. These bacteria were used as specific inoculum for the other legume planting trials, which have generally been a success. Since no legume cover failures or setbacks can be attributed to a problem with the *Rhizobium* species used, this project also appears to be a success.

EXPERIMENTAL INTERPLANTING TRIALS (#555.4)

The objectives of experimental planting trials include:

1. establishing legumes on chosen sites, using specifically prepared inoculum, and monitoring biomass, plant numbers, and nitrogen fixation throughout the growing season;
2. monitoring growth and nutrition of Douglas-fir seedlings in legume plots to determine legume effects on seedlings;
3. monitoring soil nutrient status to determine legume effects on fertility; and
4. determining, through measures of botanical composition, if legumes are exerting any measure of weed control in keeping out undesirable species.

Soil and foliar analysis results for 1982 are not yet available; and tree heights, acetylene reduction data, and botanical composition data are also currently under analysis. However, visually one can see weed control being exerted in those plots with adequate legume ground cover. Preferential browsing by deer is also evident, with red clover being their apparent "favourite" compared with other legumes and the tree seedlings.

EFFECTS OF NATURALLY OCCURRING LEGUMES ON CONIFER GROWTH AND NUTRITION (#555.5)

The objectives of this assessment are to:

1. monitor nitrogen-fixing activity of legumes using a standard acetylene reduction technique;

2. monitor soils for effects of legumes on soil fertility; and

3. sample foliage and measure trees to determine effect of legume understory on tree growth and nutritional status.

The study site is located in Chemainus Division and consists of an 8-year-old Douglas-fir plantation with an understory of lupines (Lupinus arcticus or latifolius, depending upon taxonomic work consulted). The lupines have grown into a density of 63 000 plants per hectare. The 1982 data is currently under analysis, but 1980 and 1981 data indicate a 10% greater height and 25% greater DBH in the lupine-plot trees when compared with adjacent control plot trees having a salal understory. Soil N, P and Mn are significantly greater in the lupine site, with the Mn increase also apparent in the foliar analysis as well.

FATE OF NITROGEN AND ITS EFFECT ON PHOSPHORUS IN FOREST SOIL-PLANT SYSTEMS (#515.1)

The objectives of this project are to:

1. establish a site at which plant nutrient dynamics can be monitored for several years, with special attention to nitrogen and its interrelation with P and S;

2. determine the proportion of added nitrogen that is incorporated into trees, and test the hypothesis that nitrogen application affects phosphatase and sulfatase activity, as well as the potential to supply P and S from organic form;

3. examine in detail, the fate of residual nitrogen (that nitrogen not initially incorporated into above ground material); and

4. examine in detail, the dynamics of added nitrogen and possibly P and S through litter and soil components with special emphasis on biomass and the "active fraction".

The experimental design allows for the evaluation of two nitrogen sources (urea and ammonium nitrate) in both spring and fall applications. A completely randomized design was used consisting of three representatives of the following five treatments: control, spring-NH_4NO_3, spring-urea, fall-urea, and fall NH_4NO_3. All fertilizer applications were at a rate of 200 kg N/ha.

In 1982, work accomplished included both fertilizer applications, complete instrumentation of the site, foliar sampling on five occasions, and soil sampling on three occasions.

INTERACTIONS OF ALDER AND DOUGLAS-FIR (#552.9)

The objective of the study is to examine competition between alder and Douglas-fir on Mt. Benson through the removal of the alder and additions of N, P and S fertilizers. In 1982, alder was removed and fertilizer applied.

Western Forest Products Ltd.

ASSESSMENT OF RE-ESTABLISHMENT TECHNIQUES FOR HIGH SITE CUTOVER LANDS (#25-001)

The objectives are to compare combinations of fertilization, three levels of weed control, and browse repellent on growth of 1+0 mudpack and 2+0 root pruned Douglas-fir seedlings following planting.

Second-year measurements were carried out and are being analysed. Analysis of first year results showed larger 2+0 stock grew 44% more than 1+0 mudpacks. Fertilization with DAP gave a 20% gain in size with weed control, but only 8% with no weed control. Weed control alone gave an 11% gain. The smaller mudpack stock responded more to fertilization and to weed control than the larger stock.

ECOSYSTEM MAPPING - TFL 6 (#6-001)

This project is an evaluation of the effects of cultivation, slashburning and weed control on the establishment and growth of western hemlock, western redcedar and amabilis fir on the S1 (CH phase) ecosystem. The trial was planted in February 1982 at Holberg (TFL 6, Block 4).

The trial has been assessed for survival which averaged 89%. Some damage from an escaped slashfire occurred. The trial is still operational however.

*EFFECTS OF SLASHBURNING ON NUTRIENT CONCENTRATIONS (#25-003)

This was a preliminary study to assess the impact of slashburning on soils on the upper San Juan ridge at an elevation of approximately 800 m.

Results of nutrient analysis and duff reduction measurements suggest that losses were not severe enough to warrant further intensive studies into nutrient cycling in this area at the present time.

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*Funded in 1981/82

KAMLOOPS FOREST REGION

Weyerhaeuser Canada Ltd.

STAND DENSITY MANAGEMENT IN LODGEPOLE PINE: ADOPTING THE DENSITY MANAGEMENT DIAGRAM APPROACH

A "density management" diagram, based on yield-density "laws" first suggested by Japanese researchers, Langsaeter's quantitative concept of growth, and imminent competition-mortality and relative density concepts developed by Drew and Flewelling, is being investigated as a possible basis for defining optimum management regimes for lodgepole pine.

Data have been graciously contributed by co-operators from around the world (Canada, U.S., Finland, Sweden, New Zealand, U.K.), and preliminary analyses completed. Co-operators are presently reviewing the use of their data sets, and further analysis is planned when comments are received. A density management diagram will be constructed and sample management regimes postulated for lodgepole pine.

PUBLICATIONS

Binkley, D. 1983. Ecosystem production in Douglas-fir plantations: Interaction of red alder and site fertility. Forest Ecology and Management 5:215-227.

Binkley, D., J.D. Lousier and K. Cromack, Jr. [1983]. Ecosystem effects of Sitka alder in a Douglas-fir plantation. Forest Science In press.

LICENSEE EXPERIMENTAL PROJECTS
(approved for funding in 1982/83)

Sect 88 Number	Licensee Project Number	Project Title	Company
		VANCOUVER FOREST REGION	
HV99001	616-3	Landslide inventory - TFL 21	MB
HV99002	616-12	Landslide inventory - TFL 20	MB
HV99003	316-1	Regeneration failure on south-facing aspects	MB
HV99005	6-001	Ecosystem mapping - TFL 6	WFP
HV99006	515-1	Fate of nitrogen and its effect on phosphorus in forest soil-plant systems	MB
HV99007	616-17	Second growth - deer winter range study	MB
HV99013	555-2	Field survey of legumes in Coastal B.C.	MB
HV99014	555-3	Isolation and selection of Rhizobium species	MB
HV99015	555-4	Experimental interplanting trials	MB
HV99016	555-5	Effects of naturally occurring legumes on conifer growth and nutrition	MB
HV99019	341-3	Western redcedar container trial	MB
HV99020	2-017	Impact of deer browsing on young Douglas-fir plantations and assessment of methods to reduce damage	CZ
HV99021	552-9	Interactions of alder and Douglas-fir	MB
HV99024	25-001	Assessment of re-establishment techniques for high site cutover lands	WFP
HV99025	25-002	Evaluation of establishment regimes applicable to the S1 (CH phase) Ecosystem Association in TFL 25, Block 4	WFP

HV99029	22-09-01	An ecosystem evaluation of forests on the West Coast of Vancouver Island with emphasis on the wet subzone of the CWH Biogeoclimatic Zone	BCFP
HV99030	22-08-01	Soil-site study	BCFP
HV99031	22S-79-3	An evaluation of the growth response to fertilization of Douglas-fir and western hemlock on the Tofino-Ucluelet Lowlands	BCFP
HV99032	555-7	Legume-conifer-wildlife interaction study	MB
HV99035	37-003	Identification of ecosystem associations in the Nimpkish Valley	CFP
HV99036	2-014	Nitrogen fertilization of coastal western hemlock	CZ
HV99037	2-002	The effect of thinning and fertilizaton on the growth and yield of second-growth stands	CZ
HV99038	491-2	Operational brush control trial	MB
HV99042	123-1	Impact of prescribed burning on forest productivity	MB
HV99045	22-006	Hydrologic rate of cut analysis	BCFP
HV99046	22-007	Alternative browse study-literature survey	BCFP
HV99048	22-008	Growth modelling of Douglas-fir	BCFP

KAMLOOPS FOREST REGION

HK09901		Stand density in lodgepole pine: Adopting the management diagram approach	Weyco

PRINCE RUPERT FOREST REGION

ER06006		Slope stability and geotechnical summary TSHL A10660 - Mid Coast TSA	Weldwood
ER07020		Ecosystems of Block 18 of TFL 2, Queen Charlotte Islands	CZ

ER07021	Ecosystems of Tree-Farm Licence 24, Queen Charlotte Islands, B.C.	WFP
ER99001	Skowkowna Creek Terrain - vegetation mapping relationships	MB
EP99002	Slope stability assessment (three classes) TFL 2 Block 18, Queen Charlotte Islands	CZ
ER99005	Landslide inventory TFL 39 Block 6, Queen Charlotte Islands	MB
HR99007	Slope stability hazard classification (5 classes) Rennell Sound and Davidson Creek	CIPA

CARIBOO FOREST REGION

C8102	Stock trials for brushy sites	Weldwood

PERSONNEL OF THE RESEARCH BRANCH AT MARCH 31, 1983

DR. J.A. DANGERFIELD, DIRECTOR

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SILVICULTURE

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LIST OF TREES

COMMON NAME	BOTANICAL NAME
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
subalpine fir	*Abies lasiocarpa* (Hook.) Nutt.
amabilis fir	*Abies amabilis* (Dougl.) Forbes
noble fir	*Abies procera* Rehd.
grand fir	*Abies grandis* (Dougl.) Lindl.
lodgepole pine	*Pinus contorta* Dougl. ex Loud.
western white pine	*Pinus monticola* Dougl. ex D. Donn
Ponderosa pine	*Pinus ponderosa* Dougl. ex Laws. and Laws.
Scots pine	*Pinus sylvestris* L.
red pine	*Pinus resinosa* Ait.
whitebark pine	*Pinus albicaulis*
Sitka spruce	*Picea sitchensis* (Bong.) Carr.
white spruce	*Picea glauca* (Moench) Voss
Engelmann spruce	*Picea engelmannii* Parry ex Engelm.
Norway spruce	*Picea abies* (L.) Karst.
western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
mountain hemlock	*Tsuga mertensiana* (Bong.) Carr.
western redcedar	*Thuja plicata* Donn
yellow-cedar	*Chamaecyparis nootkatensis* (D. Don) Spach
Port Orford cedar	*Chamaecyparis lawsoniana* (A. Murr.) Parl.
western larch	*Larix occidentalis* Nutt.
alpine larch	*Larix lyallii*
red alder	*Alnus rubra* Bong.

BIOGEOCLIMATIC UNITS CITED

- BWBS - Boreal White and Black Spruce Zone
  - BWBSc Un-named Subzone - Peace River area
  - BSBSd Un-named Subzone - Northeast coal area

- CCPH - Coastal Cedars - Pine - Hemlock Zone

- CWH - Coastal Western Hemlock Zone
  - CWHb Wetter Maritime Coastal Western Hemlock Subzone
  - CWHf Northern Amabilis Fir Coastal Western Hemlock Subzone
  - CWHg Queen Charlotte Islands Coastal Western Hemlock Subzone
  - CWHh Mid-coast Drier Transitional Coastal Western Hemlock Subzone
  - CWHi Mid-coast Wetter Maritime Coastal Western Hemlock Subzone

ESSF - Engelmann Spruce - Subalpine Fir Zone

ESSFa	Dry Southern Cordilleran Forested Engelmann Spruce - Subalpine Fir Subzone
ESSFc	Moist Southern Forested Engelmann Spruce - Subalpine Fir Subzone

ICH - Interior Cedar - Hemlock Zone

ICHa	Moist Southern Interior Cedar - Hemlock Subzone
ICHa1	Kootenay Moist Southern Interior Cedar - Hemlock Variant - Lower Columbia
ICHa2	Kootenay Moist Southern Interior Cedar - Hemlock Variant - Upper Columbia
ICHb	Wet Interior Cedar - Hemlock Subzone
ICHd	Moist Warm Southern Interior Cedar - Hemlock Subzone
ICHf	Very Wet Northern Interior Cedar - Hemlock Subzone
ICHg	Northern Transitional Interior Cedar - Hemlock Subzone
ICHj	Moist Northern Interior Cedar - Hemlock Subzone
ICHk	Wet Northern Interior Cedar - Hemlock Subzone

IDF - Interior Douglas Fir Zone

IDFg	Dry Cordilleran Interior Douglas Fir Subzone
IDFg1	Windermere Lake Dry Cordilleran Interior Douglas-fir Variant
IDFg2	Southern Rocky Mountain Trench Dry Cordilleran Interior Douglas-fir Variant
IDFg3	Kootenay - Columbia Dry Cordilleran Interior Douglas-fir Variant

MH - Mountain Hemlock Zone

MHa	Maritime Forested Mountain Hemlock Subzone

MS - Montane Spruce Zone

MSa	Dry Southern Cordilleran Montane Spruce Subzone

PPBG - Ponderosa Pine - Bunchgrass Zone

SBS - Sub-Boreal Spruce Zone

SBSb	Dry Cool Southern Sub-Boreal Spruce Subzone
SBSe	"Subalpine Fir" Sub-Boreal Spruce Subzone
SBSe2	Un-named Variant - Salmon River Area
SBSf	Wet Sub-Boreal Spruce Subzone
SBSh	Dry Eastern Cordilleran Sub-Boreal Spruce Subzone
SBSj	Un-named Subzone - McGregor Plateau Area
SBSk	Dry Warm Southern Sub-Boreal Spruce Subzone